*The* JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA
*DEVOTED TO SCIENCE AND THE MECHANIC ARTS*

VOL. CLXX AUGUST, 1910 No. 2

# RECENT PROGRESS IN THE CHEMISTRY OF THE SUGARS.

BY
JOSEPH SAMUEL HEPBURN, A.M., M.S,
Secretary of the Section.

(*Presented at a Stated Meeting of the Section of Physics and Chemistry, held Thursday, May 12, 1910.*)

[This paper reviews the work of Emil Fischer upon sugars and ferments. The syntheses of monoses, disaccharides and glucosides are described. The fermentation of the sugars and the action of the various inverting enzymes are discussed, as is also the lock-and-key theory of enzyme action. The splitting of racemic sugar derivatives into their active components, and asymmetric syntheses within the sugar group are also considered.]

FOODS fall into three great divisions, the fats and oils, the carbohydrates or sugars, and the proteins or nitrogenous foods. Of the three classes, the sugars are in a sense the most important, for plants synthesize carbohydrates from the carbon dioxide of the air by means of their chlorophyll; the carbohydrates thus produced may serve as a source of fat and protein. Exact experiments upon metabolic assimilation have shown that formation of fat from carbohydrate occurs in the animal body; in the vegetable world, the unripe seeds of certain plants like rape and the peony contain large quantities of starch and sugar, which entirely disappear and are replaced by oil, when the seeds ripen or even upon storage after the removal of the seeds from the

[NOTE.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.]

mother plant. This transformation of carbohydrate into fat, which at first appears rather complicated, is in fact quite simple. Glucose contains a normal chain of six carbon atoms, glycerol contains three carbon atoms; by division of the glucose chain and reduction, one molecule of glucose may give rise to two molecules of glycerol. By condensation of three molecules of glucose, accompanied by reduction and the formation of a carboxyl group, stearic and oleic acids, with their normal chains of eighteen carbon atoms, may be formed. In a similar way palmitic acid, which contains a normal chain of sixteen carbon atoms, may be formed by the condensation of one molecule of hexose and two molecules of pentose, although the union of three hexose molecules, followed by the elimination of two carbon atoms, would also give rise to palmitic acid. By the union of glycerol and the fatty acids, the fats and oils are then produced. Proteins are synthesized by plants from carbohydrates and inorganic nitrogen and sulphur compounds.[1]

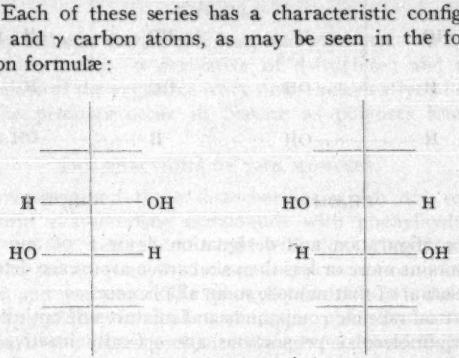
Through the labors of Chevreul and others, the chemical nature of the fats and oils was early recognized. While the proteins have been the subject of many researches, the investigation of these compounds from the standpoint of pure chemistry and their synthesis are the work of Emil Fischer, whose investigations upon amino acids, polypeptides, and proteins were recently reviewed before the Section by Dr. Bradbury.[2] From time to time the sugars and their derivatives have attracted the attention of chemists, witness Scheele's work upon mucic acid,—the "acid of sugar of milk,"[3] and the study of amygdalin and emulsin by Liebig and Wöhler.[4] However, the synthesis of the sugars, the deduction of their configuration, and the demonstration of their relation to each other is a triumph of the last quarter of a century and is due to Emil Fischer. In his investigations upon the sugars, Fischer has not confined himself within the boundaries of chemistry, but has also entered the domain of biology, in his studies of the action of enzymes upon the sugars and their derivatives.

## NOMENCLATURE OF THE SUGARS.[5]

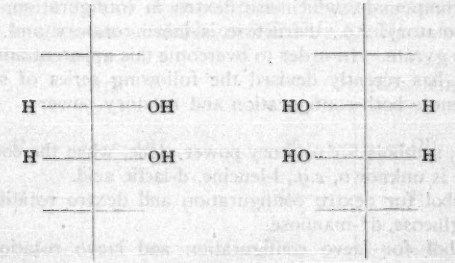
The sugars fall into two groups, the monoses and the polyoses. The monoses or simple sugars are either aldehyde-alcohols (aldoses), or ketone-alcohols (ketoses); they have the general

formula $C_nH_{2n}O_n$, and contain from two to nine carbon atoms in the molecule, whence they are called diose, triose, tetrose, pentose, hexose, heptose, octose, nonose. Thus glucose is an aldohexose, fructose a ketohexose.

The letters d- (dextro) and l- (laevo), applied to a monose or its derivatives, denote the configuration of that sugar. The hexoses fall into two series, the mannite series and the dulcite series. Each of these series has a characteristic configuration at the $\beta$ and $\gamma$ carbon atoms, as may be seen in the following projection formulæ:



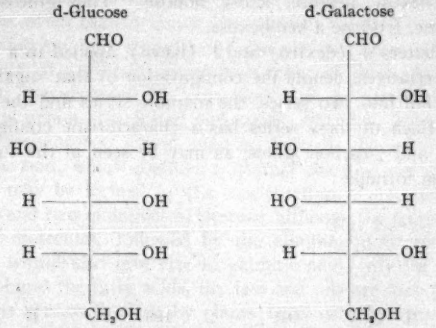

Mannite Series




Dulcite Series

The hexoses of the mannite series derive their configuration and designation of dextro or laevo from their relation to d-glucose, while the configuration and designation d- or l- are deter-

mined for the hexoses of the dulcite series by their relation to d-galactose.




The configuration and designation d- or l- of any monose which contains more or less than six carbon atoms are determined by the relation of that monose to an aldohexose.

Both true racemic compounds and mixtures of optical antipodes in equimolecular proportions are optically inactive by external compensation, although they contain asymmetric carbon atoms. Such compounds are designated by the letters dl-.

All compounds, which are dextro in configuration, are not dextro rotatory, *e.g.*, d-fructose is laevo rotatory and l-xylose is dextro gyrate. In order to overcome this apparent ambiguity, Fischer [6] has recently devised the following series of symbols, which denote both configuration and rotatory power:

d- and l-, symbols for rotatory power alone, when the configuration is unknown, *e.g.*, l-leucine, d-lactic acid.

d°-, symbol for dextro configuration and dextro rotation, *e.g.*, d°-glucose, d°-mannose.

l°-, symbol for laevo configuration and laevo rotation, *e.g.*, l°-glucose, l°-mannose.

d'-, symbol for dextro configuration and laevo rotation, *e.g.*, d'-fructose.

l'-, symbol for laevo configuration and dextro rotation, *e.g.*, l'-xylose.

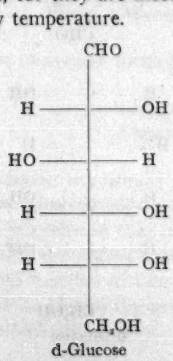
Of the polyoses, only certain disaccharides or hexabioses,—compounds of the formula $C_{12}H_{22}O_{11}$,—have been synthesized. Their molecular formula shows that they are formed by the union of two hexose molecules with the elimination of one molecule of water. In mode of synthesis and in certain of their reactions, the disaccharides resemble the synthetic glucosides. The higher polyoses have the formula

$$(C_6H_{10}O_5)_n.$$

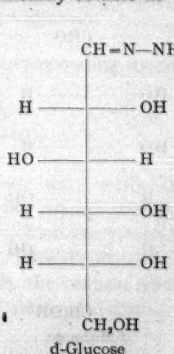
This group includes starch, cellulose, and glycogen,—derivatives of d-glucose; inulin,—a derivative of d-fructose; and the reserve cellulose of the vegetable ivory nut,—a derivative of d-mannose. The pentoses occur in Nature as polyoses known as pentosans.

### THE REACTIONS OF THE MONOSES.

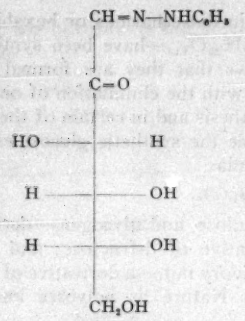
The monoses and those disaccharides which are reducing sugars form characteristic compounds with phenylhydrazine.[7] This reagent first reacts in the cold with the carbonyl group of the sugar to form a phenylhydrazone,—a reaction common to all aldehydes and ketones. The phenylhydrazones of the sugars are usually soluble in cold water; the phenylhydrazones of d-mannose,[8] l-mannose,[9] and of certain monoses of higher carbon content (α-glucooctose, glucononose [10]; d-mannoheptose, d-mannooctose, d-mannononose [11]; α-galaheptose, galaoctose [12]; l-mannoheptose [13], and rhamnoheptose [14]) form exceptions to this rule, for they are insoluble or difficultly soluble in water of ordinary temperature.



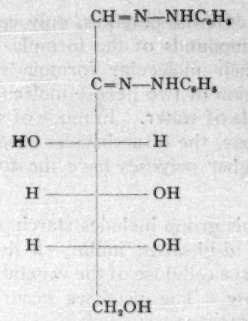

d-Glucose




d-Glucose
Phenylhydrazone



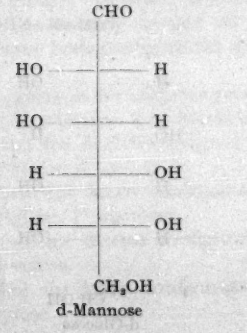

Intermediate Oxidation Product



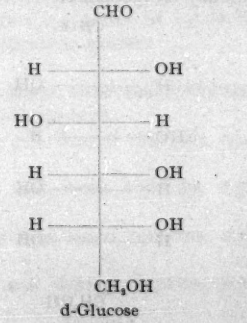

Phenyl d-Glucosazone

At the temperature of the water-bath, the reaction proceeds a step farther and a compound, known as an osazone, is produced. The alcohol group, which is in the α position to the original carbonyl group, is itself oxidized to a carbonyl group by the phenylhydrazine, which is reduced to aniline and ammonia. This newly formed carbonyl group immediately combines with phenylhydrazine to form the osazone.

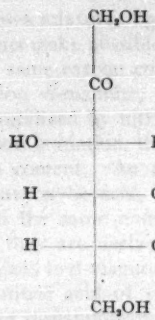
When several sugars differ in configuration only at the α carbon atom, they will yield the same osazone, thus d-glucose, d-mannose and d-fructose all give rise to phenyl d-glucosazone.



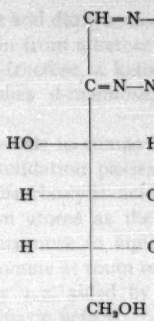

d-Mannose




d-Glucose




d-Fructose




Phenyl
d-Glucosazone

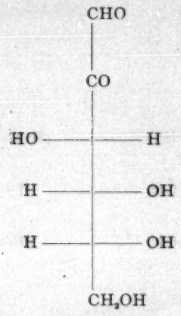
In a similar way, d-galactose and d-talose yield the same osazone,—phenyl d-galactosazone.[15] The osazones are crystalline compounds, and are useful in the separation and identification of the sugars. The molecular formula of a sugar may be determined by means of its osazone. By elementary analysis the empirical formula $CH_2O$ is deduced for both d-mannose and d-mannoheptose. However, upon elementary analysis of the osazones of these sugars, the molecular formulæ are found to be:

Phenyl d-Glucosazone (osazone of d-Mannose), $C_{18}H_{22}N_4O_4$;
Phenyl d-Mannoheptosazone, $C_{19}H_{24}N_4O_5$;

whence the molecular formulæ of the corresponding monoses:

d-Mannose, $C_6H_{12}O_6$;
d-Mannoheptose, $C_7H_{14}O_7$.

The osazones are usually insoluble even in hot water; the osazones of the disaccharides, maltose and lactose, are soluble in hot water and insoluble in cold water. Ice-cold concentrated hydrochloric acid[16] decomposes the osazones; phenylhydrazine hydrochloride and a series of new compounds, the osones, result; for instance, from phenyl d-glucosazone is obtained d-glucosone:




d-Glucosone

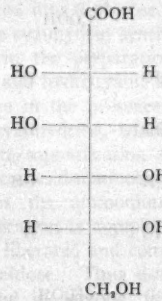
Since hydrochloric acid may hydrolyze the osone of a disaccharide, a special method has been devised in order to prepare the osones of the disaccharides from the corresponding osazones. The aqueous solution of the osazone is boiled with benzaldehyde; a soluble osone and insoluble benzaldehyde phenylhydrazone are formed,[17] thus maltosazone gives rise to a solution of maltosone.

d-Glucosone is reduced to d-fructose by the action of zinc dust and acetic acid.[18] Hence d-glucose, an aldose, may be converted into phenyl d-glucosazone, then into d-glucosone, and the latter may be reduced to d-fructose, a ketose; *i.e.*, an aldose may be transformed into a ketose of the same carbon content.

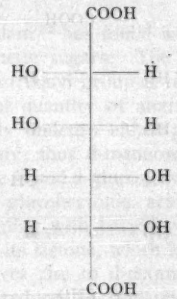
The oxidation and reduction products of the monoses are of great importance. Sodium amalgam reduces both aldoses and ketoses to the corresponding polyhydric alcohols; the earlier stages of the reduction are carried out in dilute sulphuric acid solution and the later stages in a weakly alkaline solution; thus d-mannose reduces to d-mannite [8] and d-fructose reduces to d-mannite and d-sorbite.[19] The polyhydric alcohols may be oxidized to sugars; the usual oxidizing agents are bromine and sodium carbonate, and nitric acid. Bromine and sodium carbonate give rise to a mixture of aldose and ketose, while aldose chiefly is formed by the action of nitric acid.[20] Thus d-mannite is oxidized to d-mannose by nitric acid at the temperature of the water bath,[21] and glycerol in aqueous solution is converted by sodium carbonate and bromine at room temperature into glyce-

rose [22]—a mixture of glyceraldehyde and dioxyacetone.[23] These reactions make possible the transition from a ketose to an aldose of the same carbon content, *e.g.*, d-fructose, a ketose, yields on reduction d-mannite, which furnishes d-mannose, an aldose, when oxidized by nitric acid.

Upon oxidation, the ketoses give rise to compounds of lesser carbon content. An aldose upon oxidation passes first into a monocarboxylic acid, then into a dicarboxylic acid; both acids contain the same number of carbon atoms as the sugar from which they are derived. Thus d-mannose in aqueous solution is oxidized to d-mannonic acid by bromine at room temperature,[24] while nitric acid of specific gravity 1.2, aided by gentle heat, oxidizes d-mannose to d-mannosaccharic acid.[25]

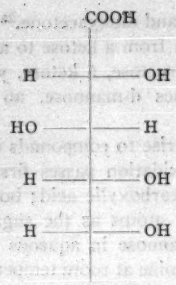



d-Mannonic Acid

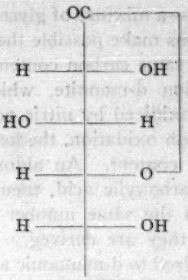



d-Mannosaccharic Acid

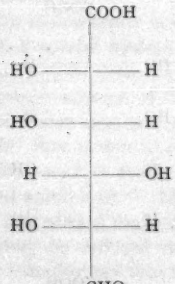
Upon evaporation of their aqueous solution, the monocarboxylic acids and certain of the dicarboxylic acids form lactones. These lactones are reduced by sodium amalgam in the presence of dilute sulphuric acid; cooling and shaking are essential for proper reduction. The lactones of monocarboxylic acids are reduced to aldoses, thus d-mannonic lactone reduces to d-mannose.[26] d-Saccharic acid is the dicarboxylic acid derived from d-glucose; it forms a lactone which reduces to glucuronic acid,—an aldehyde acid,—then to d-gulonic acid; the latter forms a lactone which yields d-gulose upon reduction.[27]



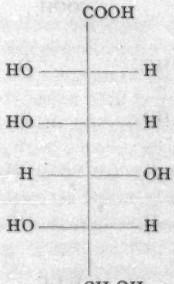

d-Saccharic Acid



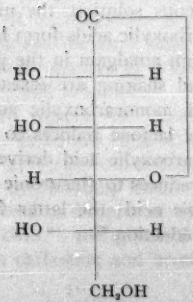

d-Saccharic Lactone



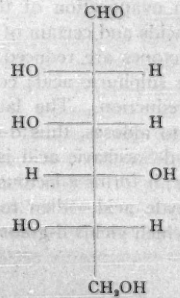

Glucuronic Acid




d-Gulonic Acid




d-Gulonic Lactone




d-Gulose

When a monocarboxylic acid is heated with quinoline at 140° C.[28] or with aqueous pyridine under pressure at 140° C.[29], a partial transposition of the hydrogen atom and hydroxyl group occurs at the carbon atom which is in the α position to the carboxyl group. The partial transformation of the pentonic acids is carried out at a lower temperature, thus l-arabonic acid undergoes a partial change into l-ribonic acid at 130° C.[30] and l-xylonic acid into d-lyxonic acid at 135° C.[31] If two sugars differ in configuration only at the α carbon atom, this rearrangement makes possible the transition from the one sugar to the other, thus d-glucose may be oxidized to d-gluconic acid, which is partially transformed into d-mannonic acid when heated to 140° C. with quinoline; the lactone of d-mannonic acid is then reduced and d-mannose is obtained. In like manner d-mannose may be converted into d-glucose.

The cyanhydrin synthesis of Kiliani[32] has found wide application in the preparation of synthetic sugars. The reducing sugars add hydrocyanic acid at the carbonyl group at room temperature in the presence of a slight quantity of ammonia and form cyanhydrins, which frequently undergo either partial or complete saponification spontaneously; thus d-mannose cyanhydrin becomes d-mannoheptonic amide[33] and d-glucose cyanhydrin becomes the ammonium salt of glucoheptonic acid.[32] The saponification is completed by warming with baryta water; the acid is liberated and converted into its lactone, which is reduced to an aldose. Thus d-mannose gives rise to d-mannoheptonic acid and its lactone, this lactone reduces to d-mannoheptose; an aldohexose has been converted into an aldoheptose; by the same procedure d-mannoheptose may be converted into d-mannooctose, and the latter into d-mannononose. Hence by means of this synthesis, one may pass from any reducing sugar to its higher homologues.

Ruff[34] has discovered a reaction which makes possible the transition from an aldose to its lower homologues. The aldose is oxidized to its monocarboxylic acid and the latter is converted into its calcium salt. Hydrogen peroxide reacts with this calcium salt in the presence of basic ferric acetate and forms a new aldose, the next lower homologue of the original aldose; water and carbon dioxide are the other products of the reaction; *e.g.*, d-glucose is converted into d-gluconic acid, then into cal-

cium d-gluconate; the latter, upon reacting with 1.19 per cent. hydrogen peroxide and basic ferric acetate, gives rise to d-arabinose, the optical antipode of natural l-arabinose.

The aldoses possess an asymmetric molecular structure, *i.e.*, the two terminal groups are unlike, hence the number of isomeric aldoses of any given carbon content is expressed by the formula $2^n$, in which $n$ represents the number of asymmetric carbon atoms in the molecule. The polyhydric alcohols and the dicarboxylic acids have a symmetric molecular structure, *i.e.*, the two terminal groups are alike, and the number of isomers is expressed by the formula of van t' Hoff $2^{\frac{n}{2}-1}(2^{\frac{n}{2}}+1)$ when $n$ is even, and by the formula of Fischer $2^{n-1}$ when $n$ is uneven. Hence eight aldopentoses and four trioxyglutaric acids are possible, for three asymmetric carbon atoms are present. The aldohexoses and their acids contain four asymmetric carbon atoms, therefore sixteen aldohexoses and ten tetrahydroxy-dicarboxylic acids are possible.[20]

## THE HEXOSES.

Theory calls for eight aldohexoses in the mannite series, the entire eight isomers have been prepared; they fall into four sets of optical antipodes, d- and l-glucose, d- and l-mannose, d- and l-gulose and d- and l-idose.

d-Glucose has been synthesized by the reduction of d-gluconic lactone.[26] d-Glucose is found in Nature in honey and fruits and, as a polyose, in starch, cellulose and glycogen.

d-Mannose is formed by the oxidation of d-mannite with nitric acid.[21] As a polyose it occurs in the salep bulb[35] and in reserve cellulose, *e.g.*, in the ivory-nut.[36]

d-Gulose is prepared by the reduction of d-gulonic lactone, which is obtained by the reduction of d-saccharic lactone.[27]

d-Idose results upon the reduction of the lactone of d-idonic acid; this acid is obtained from d-gulonic acid by heating the latter with aqueous pyridine under pressure at 140° C.[37]

The optical antipodes of these four hexoses are obtained by application of the cyanhydrin synthesis to the pentoses, and subsequent reduction of the lactones of the hexonic acids thus produced. Thus l-arabinose gives rise to l-mannonic and l-gluconic acids, which are separated by the crystallization of their lactones; l-mannonic lactone crystallizes first, while l-gluconic lactone re-

mains in the mother liquor.[38] Upon reduction these lactones yield l-mannose[9] and l-glucose[38] respectively. In like manner l-xylose gives rise to l-gulonic and l-idonic acids; l-gulonic lactone crystallizes first, while l-idonic lactone remains in the mother liquor.[37] Upon reduction the lactones are converted into l-gulose[39] and l-idose[37] respectively.

| Aldohexose | Dicarboxylic Acid |
|---|---|
| d-Glucose | d-Saccharic |
| d-Gulose | |
| l-Glucose | l-Saccharic |
| l-Gulose | |
| d-Mannose | d-Mannosaccharic |
| l-Mannose | l-Mannosaccharic |
| d-Idose | d-Idosaccharic |
| l-Idose | l-Idosaccharic |
| d-Galactose | Mucic |
| l-Galactose | |
| d-Talose | d-Talomucic |

Two ketohexoses of the mannite series,—d-fructose and l-fructose,—have been synthesized. d-Fructose, which occurs in Nature as "fruit sugar," is formed synthetically by the reduction of d-glucosone;[18] l-Fructose remains when beer yeast ferments: α-acrose (dl-fructose).[9]

But three aldohexoses of the dulcite series,—d-galactose, l-galactose and d-talose,—have been produced by synthesis, al-

though eight aldohexoses of this series are theoretically possible. By means of the cyanhydrin synthesis d-lyxose may be converted into d-galactonic acid and d-talonic acid; these acids are separated by means of their cadmium salts; after cadmium d-galactonate has crystallized, the d-talonic acid is found in the mother liquor.[40] Upon reduction the lactone of d-galactonic acid yields d-galactose,[41] while d-talonic lactone gives rise to d-talose.[15] d-Talonic acid is usually prepared by heating d-galactonic acid under pressure with aqueous pyridine at 150° C.[15] d-Galactose occurs combined with d-glucose in the natural disaccharide lactose or milk sugar.

Both the lactone and diethyl ester of mucic acid form dl-galactonic acid upon reduction; further reduction of dl-galactonic lactone gives rise to dl-galactose, from which l-galactose is obtained by fermentation with beer yeast.[42]

Theoretically ten dicarboxylic acids may be derived from the aldohexoses; all have been prepared. The table on page 97 shows the dicarboxylic acids obtained by oxidation of the aldoses.

The remaining isomers l-talomucic acid and allomucic acid have been prepared; they may be considered as derivatives of sugars which have not yet been synthesized. l-Talomucic acid is obtained by the oxidation of $\beta$-rhamnohexonic acid with nitric acid,[43] while allomucic acid is formed by heating mucic acid under pressure with aqueous pyridine at 140° C.[29]

MONOSES CONTAINING MORE OR LESS THAN SIX CARBON ATOMS.

Six aldopentoses are known, the two arabinoses, the two xyloses, l-ribose and d-lyxose. l-Arabinose and l-xylose occur in Nature as pentosans. The preparation by Ruff of d-arabinose by the oxidation of calcium d-gluconate with hydrogen peroxide in the presence of basic ferric acetate has already been described. In a similar manner, Fischer and Ruff have prepared d-xylose from calcium d-gulonate.[40] Upon heating under pressure with aqueous pyridine, l-arabonic acid and l-xylonic acid are partially converted respectively into l-ribonic acid and d-lyxonic acid. The lactone of l-ribonic acid reduces to l-ribose,[30] while that of d-lyxonic acid reduces to d-lyxose.[31]

Erythrose, a tetrose, is formed when the tetrahydric alcohol erythrite is oxidized with nitric acid. It is probably a mixture of aldose and ketose.[44]

Glycerose,[45] a triose, is a mixture of glyceraldehyde and dioxyacetone. It may be prepared by the oxidation of glycerol by nitric acid of specific gravity 1.18 at the temperature of the water-bath, or of the aqueous solution of glycerol by sodium carbonate and bromine at room temperature; it is formed by the action of dry bromine on the dry lead salt of glycerol, $C_3H_6O_3Pb$. At 0° C., in the presence of 1 per cent. sodium hydroxide, the aqueous solution of glycerose undergoes a polymerization with the formation of two hexoses, α- and β-acrose. These hexoses also result from the action of ice-cold baryta water upon acrolein bromide,[46] which is both saponified and polymerized; α-acrose is present in the polymerization product which is obtained by the action of lime water upon formaldehyde.[47] α-Acrose is dl-fructose.[9]

The diose, glycollaldehyde,[48] is the simplest sugar and is the only aldose that does not contain an asymmetric carbon atom. Its synthesis occurs in several stages. Upon treatment with bromine in the presence of calcium carbonate, the acetal of acetaldehyde is converted into the acetal of monobromacetaldehyde, from which the latter aldehyde is then isolated by distillation with anhydrous oxalic acid at the temperature of the oil-bath. Monobromacetaldehyde reacts with baryta water at 0° C. to form glycollaldehyde. Under the influence of 1 per cent. sodium hydroxide solution, glycollaldehyde is converted into a polymer, a tetrose. This tetrose forms an osazone, the properties of which are the same as those of phenylerythrosazone.

Higher monoses have been obtained from d-mannose,[11] l-mannose,[13] d-glucose[10] and d-galactose[12] by means of the cyanhydrin synthesis, combined with subsequent reduction of the lactones of the acids thus produced. d-Mannose gives rise to d-mannoheptose, d-mannooctose and d-mannononose, while l-mannoheptose has been obtained from l-mannose. From d-glucose are derived α- and β-glucoheptose; from α-glucoheptose, α- and β-glucooctose; from α-glucooctose, gluconononose; the monocarboxylic acid of a second gluconononose is also known. From d-galactose are obtained α- and β-galaheptose, and from α-galaheptose is obtained galaoctose.

Volemose[49] is a heptose; it results upon the oxidation of volemite, the heptite of the mould *Lactarius volemus*, by means of nitric acid of specific gravity 1.14 at 50° C., or of bromine and aqueous solution of sodium carbonate at 0° C.

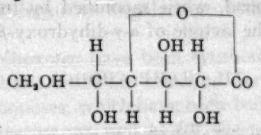
RHAMNOSE AND ITS DERIVATIVES.

Several methyl pentoses occur in Nature, *e.g.*, rhamnose,[50] chinovose,[51] fucose. Rhamnose or isodulcite, which is a constituent of the glucoside quercetrin, is the most important of these compounds. A method, devised by Wohl, has been used by Fischer for the preparation of methyl tetrose.[52] The oxime of rhamnose is treated with acetic anhydride and sodium acetate in order to obtain the tetracetyl derivative of rhamnonic nitrile; this compound is converted by ammoniacal silver oxide into a double compound of methyl tetrose and acetamide, from which the methyl tetrose is liberated by warming with dilute hydrochloric acid. A series of higher monoses, α-rhamnohexose, rhamnoheptose and rhamnooctose, have been obtained from rhamnose by means of the cyanhydrin synthesis, followed by reduction of the lactones of the acids thus formed.[14] Rhamnose in aqueous solution is oxidized by bromine to a monocarboxylic acid (rhamnonic acid),[53] which is partially transformed into isorhamnonic acid when heated with aqueous pyridine under pressure at 150–155° C.; isorhamnonic lactone reduces to isorhamnose. By a similar series of reactions, α-rhamnohexonic acid gives rise to β-rhamnohexonic acid,[43] β-rhamnohexonic lactone and β-rhamnohexose. Rhamnose then has practically all the properties of the monoses; however, one property is lacking, for upon oxidation with nitric acid the sugar yields not a dicarboxylic acid with the same number of carbon atoms, but l-trioxyglutaric acid, which contains one carbon atom less than rhamnose; the terminal methyl group is split off and the alcohol group immediately adjacent to it is oxidized to a carboxyl group. This phenomenon has prevented the determination, by purely chemical means, of the configuration of rhamnose at that carbon atom which is in the δ position to the aldehyde group.[43] Quite recently this problem has been solved by Hudson.[54]

The hypothesis of Hudson may be stated briefly: The polyhydric alcohols and the sugar acids have feeble rotatory power, while the lactones of these acids as well as the sugars and the glucosides,—all of which contain lactonic rings,—possess strong rotatory power; hence the property of producing a considerable rotation of the plane of polarized light must be due to the presence of a lactonic ring. The configuration formulæ of twenty-

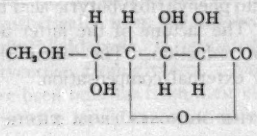
four acid lactones,—ranging from pentonic to nononic lactones,—have been derived by Fischer and his school; the rotatory power of each of these lactones has also been determined. Now if these configuration formulæ be written horizontally, it is seen that, in every case, the lactonic ring is above the chain when the lactone is laevorotatory and below the chain when the lactone is dextrorotatory, *e.g.*:

d-Galactonic Lactone



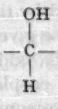
Specific rotation, —78°

d-Mannonic Lactone

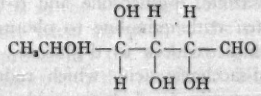


Specific rotation, +54°

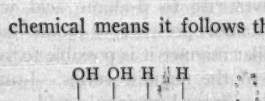
Methyl tetronic lactone has a specific rotation of —47° hence the lactonic ring must be above the chain. Therefore the configuration at that carbon atom which is in the γ position to the carboxyl group in methyl tetronic acid, and in the δ position to the aldehyde group in rhamnose, must be



Combining this fact with the partial configuration formula for rhamnose



as determined by chemical means it follows that this sugar has the configuration



LIBRARY

hence rhamnose is l-mannose, in which the terminal primary alcohol group has been reduced to a methyl group.

### AN AROMATIC MONOSE.

Phenyl tetrose, an aromatic sugar, has been synthesized from cinnamic aldehyde by a rather complicated process.[55] Cinnamic aldehyde forms a cyanhydrin, which adds bromine at the double bond. This compound, when saponified by means of mineral acid, gives rise to the lactone of α-γ-dihydroxy-β-brom-γ-phenyl-butyric acid,

$$C_6H_5.CH.CHBr.CHOHCO,$$
$$\qquad\qquad\qquad\quad O$$

which is converted into phenyltrioxybutyric acid by treatment with barium hydroxide. The lactone of the latter acid gives rise to phenyl tetrose upon reduction. The sugar thus produced is optically inactive by external compensation.

### SYNTHESIS OF THE MONOSES FROM THEIR ELEMENTS.

Both formaldehyde and glycerol have been synthesized from their elements. Formaldehyde is condensed by lime water. From glycerol are derived glycerose and acrolein bromide; the former is condensed by sodium hydroxide; the latter is both saponified and condensed by baryta water. All these condensation products contain α-acrose (dl-fructose) which is isolated as its osazone and regenerated by the reduction of the osone.

Fermentation of dl-fructose gives l-fructose. dl-Fructose reduces to dl-mannite, which is oxidized through dl-mannose to dl-mannonic acid. This acid is split by means of its strychnine and morphine salts into d-mannonic acid and l-mannonic acid. d-Mannonic lactone reduces to d-mannose, which may give rise to phenyl d-glucosazone, d-glucosone and d-fructose. d-Mannonic acid is heated with quinoline to obtain d-gluconic acid, the lactone of which reduces to d-glucose. Upon oxidation d-glucose yields d-saccharic acid, which reduces to d-gulose. d-Gulonic acid gives rise to d-idonic acid when heated with aqueous pyridine under pressure, d-idonic lactone reduces to d-idose. In a similar manner it is possible to synthesize the four [illegible] aldohexoses of the mannite series,—l-mannose, l-glucose, l-gulose and l-idose,—from l-mannonic acid.

The three known aldohexoses of the dulcite series may be synthesized from l-gulose. Calcium l-gulonate is oxidized by

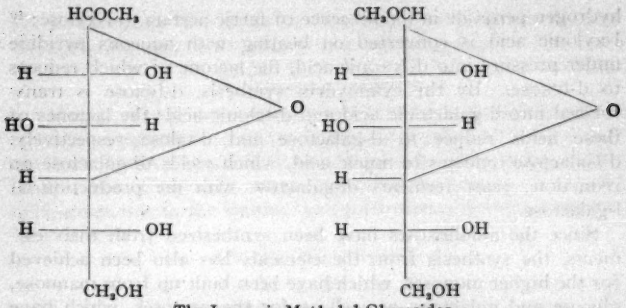
hydrogen peroxide in the presence of ferric acetate to l-xylose;[40] l-xylonic acid is converted on heating with aqueous pyridine under pressure into d-lyxonic acid, the lactone of which reduces to d-lyxose. By the cyanhydrin synthesis, d-lyxose is transformed into d-galactonic acid and d-talonic acid; the lactones of these acids reduce to d-galactose and d-talose respectively. d-Galactose oxidizes to mucic acid, which yields dl-galactose on reduction; yeast ferments dl-galactose with the production of l-galactose.

Since the aldohexoses have been synthesized from their elements, the synthesis from the elements has also been achieved for the higher monoses, which have been built up from mannose, glucose and galactose, as well as for the pentoses, which have been obtained synthetically from the aldohexoses.

The diose, glycollaldehyde, is prepared from acetaldehyde and the triose, glycerose, from glycerol. Since both acetaldehyde and glycerol have been built up from their elements, both glycollaldehyde and glycerose have been synthesized from the elements.

## THE GLUCOSIDES.

The synthetic glucosides are formed by the union of sugars and either alcohols or monohydric phenols with the elimination of water; they do not react with phenylhydrazine even at 100° C., and are readily hydrolyzed by boiling dilute acids.[56] On the other hand, when the solution of the α-hydroxyketone, benzoin, in methyl alcohol is treated with gaseous hydrogen chloride, a methyl benzoin, $C_6H_5.CO.CHOCH_3.C_6H_5$, is produced which reacts with phenylhydrazine even in the cold and which is far more resistant to the hydrolyzing action of hydrochloric acid than are the glucosides.[57] Hence the hydroxyl group at that carbon atom, which is in the α position to the aldehyde or ketone group of a sugar, takes no part in the glucoside-formation; therefore in all probability the hydroxyl group attached to the γ carbon atom enters into the reaction. Moreover, the carbon atom of the aldehyde or ketone group is rendered asymmetric by the formation of a glucoside; as a result whenever a sugar reacts with an alcohol to give rise to a glucoside, the latter exists in two forms,—the α and β varieties,—which differ in configuration only at that particular carbon atom. Thus from d-glucose and methyl alcohol are derived α-methyl d-glucoside and β-methyl d-glucoside.

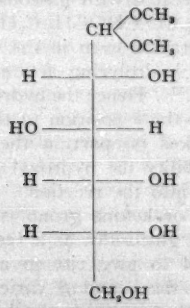



The Isomeric Methyl d-Glucosides

The α and β derivatives of the same sugar and the same alcohol differ in behavior toward enzymes and in physical properties like solubility, melting point and specific rotation.

Several methods have been devised for the preparation of synthetic glucosides. Thus the solution of a sugar in an alcohol is converted into a glucoside, if the cooled solution be saturated with gaseous hydrogen chloride.[56] This method may be used with the aldoses and with both aliphatic alcohols, and aromatic alcohols like benzyl alcohol.

If finely powdered d-glucose be shaken with a 1 per cent. solution of hydrogen chloride in methyl alcohol at room temperature, d-glucose dimethyl acetal is formed:[58]




d-Glucose Dimethyl Acetal

When the solution of the acetal in the dilute alcoholic hydrogen chloride is heated, the acetal splits off methyl alcohol and is partially converted into α- and β-methyl d-glucosides; each of the glucosides and the acetal are factors in the resulting equilibrium. The glucoside of any aldose and any alcohol may be prepared by dissolving the sugar in the alcohol, to which 1 per cent. or less of gaseous hydrogen chloride has been added, and then heating the solution under pressure at 100° C. The ketoses, —sorbose and fructose,—may be converted into glucosides in the same manner, but the heating under pressure is omitted.[58]

In another method for the preparation of glucosides,[59] the sugar is first changed into its acetyl derivative, which is then converted into an acetohalogen derivative. Thus d-glucose is transformed by boiling acetic anhydride into α-pentacetylglucose in the presence of zinc chloride, and into β-pentacetylglucose in the presence of sodium acetate; α- and β-pentacetylglucose give rise respectively to α- and β-acetochlorglucose under the action of liquefied hydrogen chloride in a sealed tube at ordinary temperature; liquefied hydrogen bromide yields the corresponding acetobromglucoses. If the solution of α-acetochlorglucose in methyl alcohol be shaken with silver carbonate at room temperature, tetracetyl α-methyl d-glucoside is formed; by subsequent saponification of the acetyl groups with barium hydroxide, α-methyl d-glucoside is obtained. In a similar way, β-acetochlorglucose yields tetracetyl β-methyl d-glucoside. In etherial solution both α- and β-acetochlorglucose react with sodium phenate to form tetracetyl β-phenol d-glucoside, from which β-phenol d-glucoside is obtained by the action of barium hydroxide. During the reaction between α-acetochlorglucose and sodium phenate, the α form is changed to the β isomer, hence α-phenol d-glucoside has never been prepared. This method may also be applied to certain disaccharides, thus octacetyl maltose is converted by liquefied hydrogen chloride into β-acetochlormaltose; this compound reacts with methyl alcohol in the presence of silver carbonate to form heptacetyl β-methyl maltoside, from which the acetyl groups are removed by means of barium hydroxide, in order to procure β-methyl maltoside.

Quite recently the glucosides of the camphors, menthol and borneol, have been synthesized.[60] Acetobromglucose and menthol react in the presence of silver carbonate to form tetracetyl

β-menthol d-glucoside, from which β-menthol d-glucoside is obtained by the action of barium hydroxide. In a similar manner acetobromglucose and d-borneol give rise to β-d-borneol d-glucoside. This method then is of the widest application, for it may be applied to monoses and disaccharides, to alcohols, phenols and camphors.

### THE DISACCHARIDES.

Several disaccharides have been synthesized. The most widely applicable method for their synthesis depends upon the reaction between a monose and an acetohalogen-monose. Thus the alcoholic solution of β-acetochlorgalactose reacts at a low temperature with the aqueous solution of glucose in the presence of an alcoholic solution of sodium to form an acetylated galactosidoglucose, from which the sugar is liberated by the action of sodium hydroxide. Galactosidoglucose is probably identical with the natural disaccharide melibiose. In a similar manner, acetochlorgalactose and galactose give rise to galactosidogalactose, while acetochlorglucose and galactose react to form glucosidogalactose.[61]

Isomaltose, a synthetic hexabiose, is a product of the action of concentrated hydrochloric acid upon glucose at a temperature of 10° to 15° C.[62]

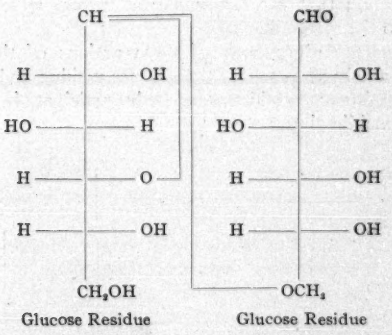
By means of enzymes[61] several disaccharides have been synthesized, of which isolactose has received the most attention. Isolactose is formed by the union of glucose and galactose, with the elimination of water, under the influence of the enzyme lactase at a temperature of 35° C. This enzyme, which occurs in kefir-granules, is also able to produce a coupling of two glucose molecules with the formation of a hexabiose. In a similar way the enzyme emulsin causes the coupling of a glucose molecule and a galactose molecule.

Bottom yeast causes fermentation of isolactose, galactosidoglucose and glucosidogalactose.[61]

The synthetic disaccharides all react with phenylhydrazine to form osazones, hence they all contain a free carbonyl group. Certain disaccharides like maltose and lactose resemble the synthetic disaccharides in the formation of osazones, and both the natural and synthetic disaccharides resemble the glucosides in their behavior toward inverting enzymes. Lactosone is hydro-

lyzed by 4 per cent. hydrochloric acid at the temperature of the water-bath into d-galactose and d-glucosone.[63] At room temperature, bromine oxidizes the aqueous solution of lactose to lactobionic acid, a monocarboxylic acid, which is converted into d-galactose and d-gluconic acid by the action of warm 5 per cent. sulphuric acid.[64] Through the cyanhydrin synthesis, lactose passes into a monocarboxylic acid, which contains thirteen carbon atoms and is known as lactosecarbonic acid;* this acid is split by warm 5 per cent. sulphuric acid into d-galactose and α-glucoheptonic acid.[65] These reactions show that the free carbonyl group of lactose must be contained in the glucose residue of that disaccharide. Maltosone is hydrolyzed by the inverting enzymes of yeast into d-glucose and d-glucosone.[17] Maltobionic acid yields d-glucose and d-gluconic acid upon hydrolysis,[66] while maltosecarbonic acid * gives rise to d-glucose and α-glucoheptonic acid.[65] These reactions of the derivatives of lactose and maltose, as well as the behavior of the sugars themselves toward enzymes, are in harmony with the following formulæ, which also express the glucosidic nature of these disaccharides:[56]

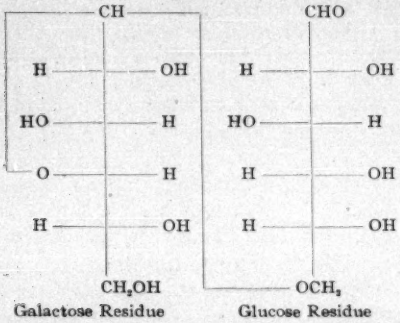
Maltose




Glucose Residue Glucose Residue

* On page vii, paragraph 93, of "Directions for Assistant Editors and Abstractors," accompanying Chemical Abstracts, 1910, IV, No. 12, the rule is given, "Names ending in -carbonsäure are to be translated *-carboxylic acid.*" Under this nomenclature, lactosecarbonic acid and maltosecarbonic acid would be termed lactosecarboxylic acid, and maltosecarboxylic acid, respectively.

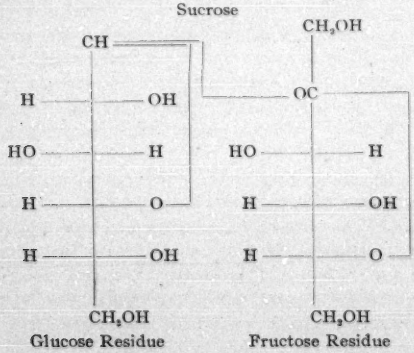
Lactose




In that glucose residue, which contains the aldehyde group in both maltose and lactose, there is a possibility that, instead of the primary alcohol group, any one of the three secondary alcohol groups, occupying the $\beta$, $\gamma$ or $\delta$ position to the aldehyde group, may take part in the anhydride formation. The fact that maltose and lactose give rise to osazones excludes from the anhydride formation that secondary alcohol group which is in the $\alpha$ position to the aldehyde group.

Since sucrose gives none of the reactions of the reducing sugars, the aldehyde group of the glucose residue and the ketone group of the fructose residue must both participate in the formation of glucosidic rings:

Sucrose



Several synthetic glucosido acids have been prepared. Thus, if the strongly concentrated, aqueous solution of d-glucose and d-gluconic acid be treated with gaseous hydrogen chloride, until the solution loses the power of reducing Fehling's solution, then the sugar and the acid have combined with the elimination of water to form glucosidogluconic acid.[67]

### ALCOHOLIC FERMENTATION OF THE SUGARS.

Only certain trioses, hexoses and nonoses are capable of undergoing alcoholic fermentation. In addition to the well-known examples, d-glucose, d-fructose and d-galactose, the following monoses are fermentable: glycerose,[68] d-mannose,[69] d-mannononose.[11] According to Buchner, alcoholic fermentation is due to the action of an endo-enzyme, zymase; this enzyme is secreted by the yeast cell, within which it remains during the life of the latter. The sugar passes by diffusion into the yeast cell and is there fermented by the enzyme. Zymase may be liberated from the yeast cell by grinding, with quartz sand, yeast which has been dried by compression, or by freezing yeast with solid carbon dioxide, then pulverizing the frozen mass. Buchner's work has been reviewed in a paper read before the Section by Dr. Bradbury.[70]

Disaccharides are first inverted by the inverting enzymes; the resulting monoses then undergo alcoholic fermentation.

### THE INVERTING ENZYMES.

In Nature are found four enzymes which exert an hydrolytic action upon the disaccharides and glucosides; they are invertin, maltase or glucase, lactase and emulsin. *Schizo-saccharomyces octosporus*, a yeast, secretes only maltase, while *Saccharomyces Marxianus*, another yeast, secretes only invertin.[71] Certain yeasts, like Frohberg yeast, secrete both invertin and maltase. Invertin is removed from the fresh yeast by water; however, maltase passes into solution only after the yeast has been ground with glass powder to rupture the cells, or after the yeast has been dried.[72] Likewise, lactose-yeast contains two enzymes, invertin, which may be removed by water, and lactase, which passes into solution after the air-dried lactose-yeast has been ground with glass powder to rupture the cells; lactase is also found in

kefir granules.[72] Emulsin, which occurs in the vegetable kingdom, *e.g.*, in almonds, was investigated by Liebig and Wöhler during their study of amygdalin and the oil of bitter almonds.[4]

Invertin inverts only sucrose.[73] Maltase produces hydrolysis of maltose and of certain α glucosides like α-methyl d-glucoside, α-methyl d-fructoside,[73] and α-ethyl d-glucoside,[74] therefore maltose belongs to the α series of glucosides. Emulsin splits lactose and certain β glucosides like β-methyl d-glucoside, β-phenyl d-glucoside,[74] β-methyl d-galactoside [58] and β-phenyl d-galactoside,[75] as well as many natural glucosides, *e.g.*, salicin, coniferin, arbutin, esculin, etc;[76] hence lactose and the natural glucosides apparently belong to the β series. Lactase causes hydrolysis of lactose [72] and of β-methyl, β-ethyl and β-phenyl d-galactosides;[77] it differs from emulsin by not acting upon β-methyl d-glucoside or amygdalin.[72]

A glucoside, which is derived from a disaccharide, may be hydrolyzed by both maltase and emulsin, but with the formation of different products. Thus β-methyl maltoside is converted into maltose and methyl alcohol by emulsin, while it is changed into d-glucose and β-methyl d-glucoside by maltase.[78] Under the influence of emulsin, amygdalin gives rise to benzaldehyde, prussic acid and a fermentable sugar (d-glucose);[4] maltase, however, changes amygdalin into d-glucose and mandelonitrile glucoside.[79] Emulsin decomposes the latter with the formation of d-glucose, benzaldehyde and hydrocyanic acid.[79]

Of the synthetic disaccharides, galactosidoglucose, glucosidogalactose and galactosidogalactose are hydrolyzed by emulsin, while isolactose is inverted by kefir-lactase.[61]

The inverting enzymes do not act upon the glucosides of sugars which have a lævo configuration, for instance, maltase does not produce hydrolysis of α-methyl l-glucoside.[74]

Inverting enzymes are found in various animal secretions and organs.[80]

### THE LOCK AND KEY THEORY OF ENZYME ACTION.

Fischer and Thierfelder [81] found that, when yeasts in pure culture were permitted to act upon nine different aldohexoses, fermentation occurred with only three of the sugars, d-glucose, d-mannose and d-galactose. Under the same conditions, of

the ketohexoses, d-fructose, l-fructose and sorbose, only d-fructose was fermented. Now d-glucose, d-mannose, d-fructose and d-galactose differ but slightly in configuration; when a yeast ferments these sugars and leaves the other hexoses unchanged, its choice is not for one of two optical antipodes, but is entirely dependent upon the configuration. Fischer and Thierfelder explain the phenomenon: "Among the agents, of which the living cell makes use, the different proteins play the leading rôle. They are likewise optically active, and, since they arise synthetically from the carbohydrates of the plants, one may indeed assume that the geometric structure of their molecules, in respect to asymmetry, is essentially similar to that of the natural hexoses. With this acceptance, it should not be difficult to understand that the yeast cells with their asymmetrically formed agent can attack and act with the production of fermentation only upon those sugars, of which the geometric structure does not differ too widely from that of glucose."

Fischer extended this theory to include the inverting enzymes. "As is well known invertin and emulsin bear many an analogy to the proteins and, like the latter, undoubtedly possess an asymmetrically constructed molecule. Their limited action upon the glucosides therefore may be explained by the hypothesis that that approach of the molecules, which is essential for the occurrence of chemical reaction, can take place only in case of similar geometric structure. To use a comparison, I will say that enzyme and glucoside must fit each other like lock and key in order to be able to exert a chemical action upon each other." [74]

"If one wishes to do justice to the fact that some yeasts can ferment a greater number of hexoses than others, then the comparison may be completed by the distinction of master key and special key." [20]

*Saccharomyces productivus* ferments d-mannose and d-fructose but has no action upon d-galactose, while *Saccharomyces cerevisiæ I* produces fermentation of all three of these sugars.[81] Now it may be considered that *Saccharomyces productivus* secretes a zymase which is a special key for d-mannose and d-fructose, while *Saccharomyces cerevisiæ I* secretes a zymase, which is a master key and acts upon not only d-mannose and d-fructose but also d-galactose.

## THE SPLITTING OF RACEMIC COMPOUNDS INTO THEIR ACTIVE CONSTITUENTS.

For the separation of racemic compounds into their active constituents, Pasteur [82] introduced three methods: fermentation, simple crystallization, and the difference in solubility of the salts of the two optical antipodes with one and the same optically active compound. Fischer has utilized all these methods in splitting the racemic compounds of the sugars into their active constituents, and has added to them a fourth method—the action of enzymes.

When beer yeast acts upon the aqueous solution of any one of the racemic hexoses,—dl-mannose,[9] dl-fructose,[9] dl-glucose,[38] dl-galactose,[42]—it ferments the dextro antipode, and thus a solution is produced which contains only the hexose of laevo configuration. The separation of racemic compounds of the sugar group into their active constituents by means of fermentation with *Penicillium glaucum* is incomplete and therefore unsatisfactory. The action of this mould upon dl-mannonic acid and upon dl-fructose has been studied.[9]

Under suitable conditions the solution of a racemic compound will deposit crystals of the two optical antipodes, which are distinguished from each other as right-handed and left-handed crystals by means of their hemihedral faces and thus may be separated mechanically. For instance, the solution of dl-gulonic lactone deposits crystals of d-gulonic lactone and of l-gulonic lactone, which may be separated mechanically.[88] The solution of methyl dl-mannoside deposits crystals of methyl d-mannoside and methyl l-mannoside at temperatures between $+2°$ and $+8°$ C.; the crystals may be separated mechanically. At temperatures above $+15°$ C., crystallization of methyl dl-mannoside, the racemic compound, occurs.[84]

If the strychnine salt of dl-mannonic acid be dissolved in hot absolute alcohol, strychnine l-mannonate crystallizes out in a few moments at the boiling temperature; the mother liquor contains the d-mannonate of the alkaloid and some of the salt of the laevo acid. The d-mannonic acid is finally isolated from the mother liquor as the morphine salt.[9]

When emulsin acts upon a racemic mixture of $\beta$-methyl d-glucoside and $\beta$-methyl l-glucoside, the $\beta$-methyl d-glucoside is

hydrolyzed by the enzyme while β-methyl l-glucoside, the optical antipode, remains unchanged. In a similar way, the yeast enzyme, maltase, acts upon α-methyl dl-glucoside, producing hydrolysis of α-methyl d-glucoside but failing to act upon α-methyl l-glucoside.[85]

### ASYMMETRIC SYNTHESIS.

Whenever compounds, which do not contain an asymmetric carbon atom, react to form a compound containing such an atom, the two stereoisomers are formed in equal quantities, and the new compound is racemic, *i.e.*, optically inactive by external compensation. Thus acetaldehyde adds prussic acid to form dl-lactonitrile, which is saponified by mineral acids with the production of dl-lactic acid.

However, if one of the reacting compounds be optically active, the reaction proceeds asymmetrically, *i.e.*, the two new compounds are formed in unequal quantities. α-Glucoheptose by the cyanhydrin synthesis gives rise to two octoic acids, α-glucooctoic acid and β-glucooctoic acid. If the addition of hydrocyanic acid occur at 20° to 25° C., the yield of α acid amounts to 73 per cent. of the theoretical yield of octoic acid, and the β acid is almost entirely absent from the product; when the reaction is carried out at 40° C., the quantity of β acid equals 13 per cent. of the theoretical amount of octoic acid, but the α acid still forms by far the greater part of the product.[10]

By the cyanhydrin synthesis, d-mannose gives rise to but one d-mannoheptoic acid; the theoretically possible isomer is not present in the mother liquor. The yield of d-mannoheptoic acid is 87.4 per cent. of the theoretical yield of heptoic acid. A study of the salts of d-mannoheptoic acid with metals and with alkaloids has shown the unitary nature of this acid.[86] Therefore this synthesis is wholly asymmetric.

Glucoside formation may occur asymmetrically. Thus methyl alcohol and d-mannose unite in the presence of 0.25 per cent. hydrogen chloride to form methyl d-mannoside; the theoretically possible isomer is not present in the mother liquor.[84] This reaction is entirely asymmetric.

It is possible to proceed from a compound containing an optically active group, and to build from this compound a second compound which will contain a new asymmetric carbon atom—the product of synthesis. The reaction proceeds in an asym-

metric way, and, after the original active group has been eliminated from the new compound, the final synthetic product will be optically active. For example, helicin (salicylic aldehyde glucoside) contains an optically active glucose group, and also forms a tetracetyl derivative. This derivative adds prussic acid to give rise to a cyanhydrin—origin of the new asymmetric carbon atom. Liquefied hydrogen chloride, in the presence of the theoretic quantity of water, saponifies the cyanhydrin to the amide of tetracetygluco-o-oxymandelic acid. The latter compound is converted into o-oxymandelic acid by warm dilute hydrochloric acid—removal of the original active group. The o-oxymandelic acid has a slight dextro rotation, but unfortunately has not been obtained crystalline.[87]

The formation of sugar from the carbon dioxide of the air in the presence of sunlight by the chlorophyll of plants is an example of asymmetric synthesis. According to Fischer, the optically active chlorophyll first combines with either carbon dioxide or its reduction product, formaldehyde. The condensation to sugar which then occurs, is influenced by the asymmetry of the chlorophyll molecule and proceeds asymmetrically. Next the sugar is liberated from the complex molecule and exists as an optically active compound by virtue of its asymmetric synthesis.[20]

Liebig and Wöhler begin the description of their classic research upon the radical of benzoic acid [88] with the following statement. Whenever, in the dark realm of organic Nature, one succeeds in finding a luminous point, which appears to us as one of the entrances by means of which we may possibly come to the right road for the investigation and recognition of this realm, then one has reason to congratulate himself, even if he be aware of the fact that the realm in question is inexhaustible.

Fischer has illumined for us three great divisions of the realm of organic chemistry, the purin bases, the amino acids, polypeptides and proteins, and the carbohydrates and their ferments.

## REFERENCES.

[1] Fischer: Die Chemie der Kohlenhydrate und ihre Bedeutung für die Physiologie. Rede, gehalten zur Feier des Stifungstages der militärärztlichen Bildungsantalten am 2 August 1894. Untersuchungen über Kohlenhydrate und Fermente, 96.

[2] Bradbury: JOURNAL OF THE FRANKLIN INSTITUTE, 1909, clxviii, 85.

[3] Chemical Essays of Charles William Scheele. Translated by Beddoes. Murray, London 1786. Re-issued by Scott, Greenwood and Co., London 1901. Essay xviii, On the Acid of Saccharum Lactis.
[4] Liebig and Wöhler: Liebig's Annalen, 1837, xxii, 1.
[5] Fischer: Berichte der deutschen chemischen Gesellschaft, 1890, xxiii, 2114; 1894, xxvii, 3189; 1907, xl, 102.
[6] Untersuchungen über Kohlenhydrate und Fermente 1884–1908, von Emil Fischer, Berlin. Verlag von Julius Springer, 1909, 896.
[7] Fischer: Berichte, 1884, xvii, 579; 1887, xx, 821.
[8] Fischer and Hirschberger: Berichte, 1888, xxi, 1805.
[9] Fischer: Berichte, 1890, xxiii, 370.
[10] Fischer: Liebig's Annalen der Chemie, 1892, cclxx, 64.
[11] Fischer and Passmore: Berichte, 1890, xxiii, 2226.
[12] Fischer: Liebig's Annalen der Chemie, 1895, cclxxxviii, 139.
[13] Smith: Liebig's Annalen der Chemie, 1892, cclxxii, 182.
[14] Fischer and Piloty: Berichte, 1890, xxiii, 3102.
[15] Fischer: Berichte, 1891, xxiv, 3622.
[16] Fischer: Berichte, 1888, xxi, 2631; 1889, xxii, 87.
[17] Fischer and Armstrong: Berichte, 1902, xxxv, 3141.
[18] Fischer: Berichte, 1889, xxii, 94.
[19] Fischer: Berichte, 1890, xxiii, 3684.
[20] Fischer: Berichte, 1894, xxvii, 3189.
[21] Fischer and Hirschberger: Berichte, 1889, xxii, 365.
[22] Fischer and Tafel: Berichte, 1887, xx, 3384.
[23] Fischer and Tafel: Berichte, 1888, xxi, 2634; 1889, xxii, 106.
[24] Fischer and Hirschberger: Berichte, 1889, xxii, 3218.
[25] Fischer: Berichte, 1891, xxiv, 539.
[26] Fischer: Berichte, 1889, xxii, 2204; 1890, xxiii, 930.
[27] Fischer and Piloty: Berichte, 1891, xxiv, 521.
[28] Fischer: Berichte, 1890, xxiii, 799.
[29] Fischer: Berichte, 1891, xxiv, 2136.
[30] Fischer and Piloty: Berichte, 1891, xxiv, 4214.
[31] Fischer and Bromberg: Berichte, 1896, xxix, 581.
[32] Kiliani: Berichte, 1885, xviii, 3066; 1886, xix, 221, 767, 1128.
[33] Fischer and Passmore: Berichte, 1890, xxiii, 2226.
[34] Ruff: Berichte, 1898, xxxi, 1573; 1899, xxxii, 550.
[35] Tollens and Gans: Berichte, 1888, xxi, 2150; Liebig's Annalen der Chemie, 1888, ccxlix, 256.
[36] Reiss: Berichte, 1889, xxii, 609. Fischer and Hirschberger: Berichte, 1889, xxii, 1155, 3218.
[37] Fischer and Fay: Berichte, 1895, xxviii, 1975.
[38] Fischer: Berichte, 1890, xxiii, 2611.
[39] Fischer and Stahel: Berichte, 1891, xxiv, 528.
[40] Fischer and Ruff: Berichte, 1900, xxxiii, 2142.
[41] Fischer: Berichte, 1890, xxiii, 930.
[42] Fischer and Hertz: Berichte, 1892, xxv, 1247.
[43] Fischer and Morrell: Berichte, 1894, xxvii, 382.
[44] Fischer and Tafel: Berichte, 1887, xx, 1088. Fischer: Berichte, 1894, xxvii, 3189.
[45] Fischer and Tafel: Berichte, 1887, xx, 1088, 3384; 1888, xxi, 2634.
[46] Fischer and Tafel: Berichte, 1887, xx, 2566.
[47] Fischer and Passmore: Berichte, 1889, xxii, 359.
[48] Fischer and Landsteiner: Berichte, 1892, xxv, 2549.
[49] Fischer: Berichte, 1895, xxviii, 1973.
[50] Fischer and Tafel: Berichte, 1887, xx, 1088; 1888, xxi, 1657, 2173.
[51] Fischer and Liebermann: Berichte, 1893, xxvi, 2415.
[52] Fischer: Berichte, 1896, xxix, 1377.
[53] Fischer and Herborn: Berichte, 1896, xxix, 1961
[54] Hudson: United States Department of Agriculture, Bureau of Chemistry, Circular No. 49, 1910: Journal of the American Chemical Society, 1910, xxxii, 338.

[55] Fischer and Stewart: Berichte, 1892, xxv, 2555.
[56] Fischer: Berichte, 1893, xxvi, 2400.
[57] Fischer: Berichte, 1893, xxvi, 2412.
[58] Fischer: Berichte, 1895, xxviii, 1145.
[59] Fischer and Armstrong: Berichte, 1901, xxxiv, 2885; 1902, xxxv, 833, 3153.
[60] Fischer and Raske: Berichte, 1909, xlii, 1465.
[61] Fischer and Armstrong: Berichte, 1902, xxxv, 3144.
[62] Fischer: Berichte, 1890, xxiii, 3687; 1895, xxviii, 3024.
[63] Fischer: Berichte, 1888, xxi, 2631.
[64] Fischer and Meyer: Berichte, 1889, xxii, 361.
[65] Reinbrecht: Liebig's Annalen der Chemie, 1892, cclxxii, 197.
[66] Fischer and Meyer: Berichte, 1889, xxii, 1941.
[67] Fischer and Beensch: Berichte, 1894, xxvii, 2478.
[68] Fischer and Tafel: Berichte, 1889, xxii, 106.
[69] Fischer and Hirschberger: Berichte, 1888, xxi, 1805; 1889, xxii, 3218.
[70] Bradbury: JOURNAL OF THE FRANKLIN INSTITUTE, 1904, clvii, 41.
[71] Fischer and Lindner: Berichte, 1895, xxviii, 984.
[72] Fischer: Berichte, 1894, xxvii, 3479.
[73] Fischer: Berichte, 1894, xxvii, 3479; 1895, xxviii, 1429.
[74] Fischer: Berichte, 1894, xxvii, 2985.
[75] Fischer and Armstrong: Berichte, 1902, xxxv, 833.
[76] Fischer: Berichte, 1894, xxvii, 2985; Zeitschrift für physiologische Chemie, 1898, xxvi, 60.
[77] Fischer and Armstrong: Berichte, 1902, xxxv, 3153.
[78] Fischer and Armstrong: Berichte, 1901, xxxiv, 2885.
[79] Fischer: Berichte, 1895, xxviii, 1508.
[80] Fischer and Niebel: Sitzungsberichte der Königlich preussichen Akademie der Wissenschaften zu Berlin, 1896, v 73.
[81] Fischer and Thierfelder: Berichte, 1894, xxvii, 2031.
[82] Pasteur: Researches on the Molecular Asymmetry of Natural Organic Products, 1860: Alembic Club Reprints, No. 14.
[83] Fischer and Curtiss: Berichte, 1892, xxv, 1025.
[84] Fischer and Beensch: Berichte, 1896, xxix, 2927.
[85] Fischer: Berichte, 1899, xxxii, 3617.
[86] Hartmann: Liebig's Annalen der Chemie, 1892, cclxxii, 190.
[87] Fischer and Slimmer: Berichte, 1903, xxxvi, 2575.
[88] Liebig and Wöhler: Annalen der Pharmacie, 1832, iii, 249.

# THE EFFECT OF CRYSTALLINE PIGMENTS ON THE PROTECTION OF WOOD.

BY

HENRY A. GARDNER.

[The writer has made a study of paint tests upon different grades and kinds of wood, and has been impressed with the uniformly bad results obtained when the wood is not properly selected.]

IT makes little difference what paint is tested when faulty wood is used, for the result in every case will be failure. A notable instance of such failure is recorded in the tests conducted at Fargo, North Dakota, by the Agricultural Experiment Station and the Paint Manufacturers' Association, where most of the wood used on the western side of the test fences (northern hard pitch pine) was extremely sappy and of a hard grain. After a few months' wear, the resinous sap, through the action of the sun, pushed itself through the paint and completely obliterated the latter in many spots. Again, at Atlantic City and at Pittsburg, in the paint tests [1] made under the inspection of the American Society for Testing Materials and the direction of the Carnegie Technical Schools, it developed that cypress and yellow pine gave unsatisfactory results in many cases. The inspectors, therefore, were forced to draw their conclusions from these tests almost universally from the white pine panels. Paint tests, therefore, if their object is to determine the value of pigments, should be made upon high grade wood, such as white pine or poplar carefully inspected and seasoned.

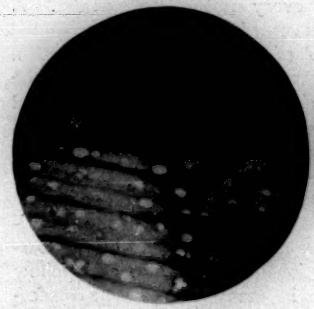
*Seasoning and Drying.*—The importance of the proper seasoning and drying of wood cannot be overestimated, as the effect of an excess of moisture in lumber is bad from every standpoint. Every one is familiar with the appearance of a

[1] In these tests, over one thousand panels of different grades of wood were painted with different pigments, alone and in combination, and in several colors. A full report of the wearing of each formula on these tests may be had by writing to the Scientific Section, Paint Manufacturers' Association, 3500 Gray's Ferry Road, Philadelphia, for Bulletins 16, 17, 25, 26, and 28.

building painted immediately upon erection in the early spring, when the excess moisture in the wood, or the moisture that comes from the plaster, works itself to the surface. The badly stained appearance of the paint, which first indicates that moisture is working through, is followed by scaling and blistering, and the effort to beautify and protect has been defeated.

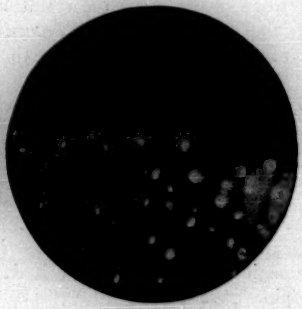
The strength of wood is also vitally affected by the moisture content. It is fairly well known that the strength begins to be greatest when the excess moisture in the cells or honeycomb part of the wood is removed, and when that point is reached where the fibres or cell walls are satisfied. Kiln drying may remove

FIG. 1.



Maple (transverse section; one-half painted with lead and zinc paint containing 10 per cent. barytes and asbestine).

FIG. 2.



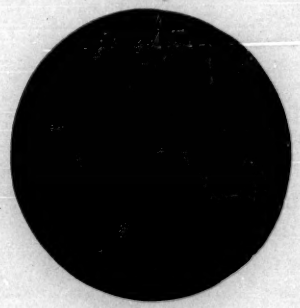
Maple (transverse section; one-half coated with white lead).

even more of this moisture, but if the moisture does not extend beyond the fibre saturation point, a fair degree of safety and strength is to be depended upon.

*Action of Crystalline Pigments.*—The effect of certain crystalline pigments in aiding the opaque white pigments in their battle to properly protect wood has been demonstrated in practice, and by test, and to-day the paint manufacturer is using these crystalline pigments in small percentage for this purpose. The filling of wood, such as floors for instance, has almost always been done by the use of pigments such as quartz silica, or very fine barium sulphate. The action of these pigments in penetrating the pores of the wood and becoming attached by

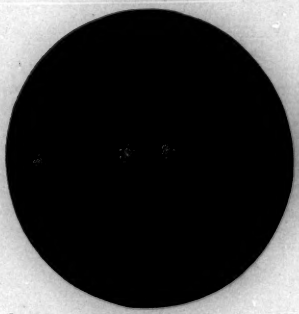
their rough surfaces, to the tentacles of the wood, is extremely important. Pigments such as zinc oxide or white lead are made up of particles more spherical and with smoother surfaces, and will not secure that same hold upon the woody fibre, obtainable

FIG. 3.



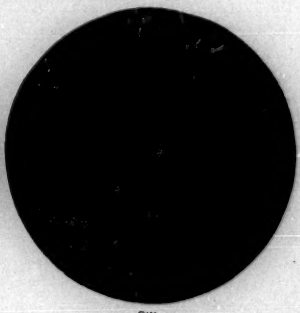
Asbestine; magnification 930.

FIG. 4.



Precipitated barium sulphate; magnification 930.

FIG. 5.

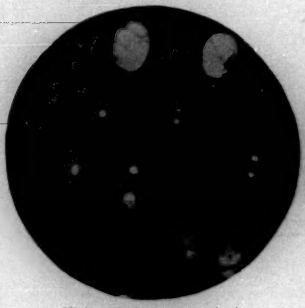


Silica.

through the use of the rougher or more crystalline pigments. The painter often uses materials such as yellow ochre for the priming coat for wood, understanding that the ochre has a high content of crystalline pigments, such as silica or silicates. It has been found, however, that a much better practice is to have the priming coat of a paint made up with a small percentage

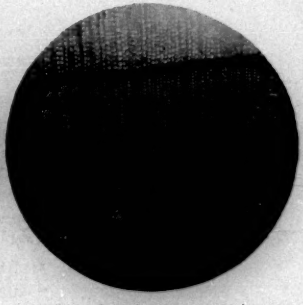
of the pure crystalline pigments. The photomicrographs (Figs. 1 and 2) show the effect of painting one coat of a paint made up on the above basis, with crystalline pigments, as against the effect of using a single pigment paint. The wood used for this test,

FIG. 6.



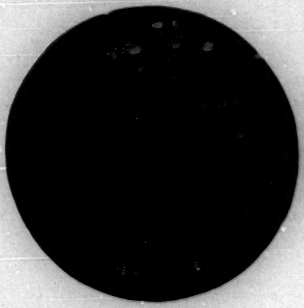
Hickory (transverse section).

FIG. 7.



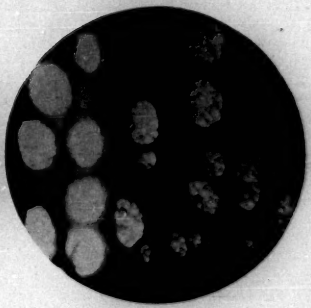
Red cedar (transverse section).

FIG. 8.



Maple (transverse section).

FIG. 9.

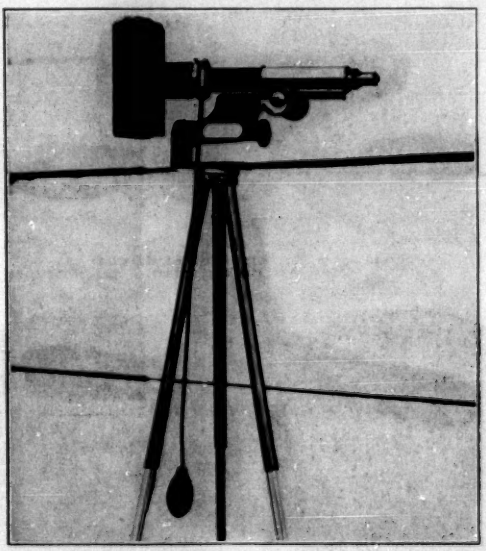


Locust (transverse section).

maple, is not one commonly used for exterior purposes, but its fibre offers even more resistance to a paint than the ordinary woods used in the building of houses. It can be seen, however, from the photomicrographs that excellent penetration and filling of the cells has been obtained. Figs. 3, 4, and 5 show magnified views of some of the crystalline pigments in their dry condition.

*The Treatment of Refractory Woods.*—Yellow pine, cypress and other hard woods used in the construction of frame buildings, generally contain a large quantity of pitch and sap which tend to harden the grain and make penetration of the paint almost impossible. To meet such conditions, the painter generally reduces the paste or liquid paint with turpentine or other volatile

FIG. 10.



Gardner's photomicroscope in place for field work.

solvents that will act as accelerators in carrying the paint into the fibre of the wood, and even assist in amalgamating the paint with the resins contained in the wood. The use of new solvents, such as benzol, xylol, and toluol, to replace turpentine, is being experimented with, and so far very good results have been obtained. The penetrative values of the above-mentioned coal-tar distillates are high, and their price, as compared with the

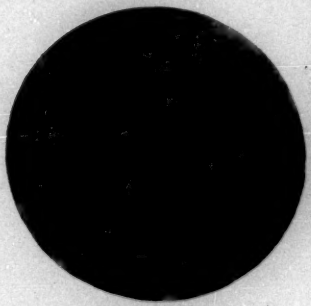
price of turpentine, will probably make them commercially acceptable. Figs. 6, 7, 8, and 9 show transverse sections of a few American woods. Magnification, 56.

*The Photomicroscope as an Adjunct in Field Inspections.*—

FIG. 11.

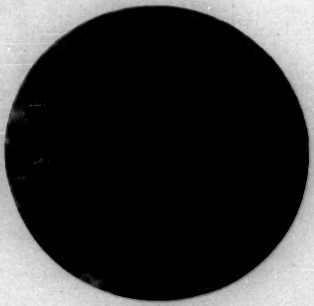
Photomicrograph of surface painted with white lead showing checking present.

FIG. 12.



Photomicrograph of a concrete wall.

FIG. 13.



Photomicrograph of a piece of steel showing rust developing on surface.

The paint chemist is often called upon to report upon the value of a paint that has suffered exposure. The conditions generally looked for as being indicative of the value of a paint are hiding power, gloss, color maintenance, degree of chalking, general condition, and checking. Most of these conditions are easily

determined, except the latter, which cannot always be seen by the naked eye. A great many paints soon after exposure become very hard and brittle, and fine checking starts in. In order to determine the amount of checking present, and permanently record the condition, the writer has developed an apparatus which has given most satisfactory results. Its value in the field, to the paint inspector, cannot be overestimated. The apparatus (Fig. 10) is made in the following manner:

The arm and body of a microscope containing a draw tube fitted with objective and eyepiece is mounted in a horizontal position on a solid iron base, the bottom of which is punched and threaded to the standard size to receive the screw from the top of a heavy tripod. This latter piece of apparatus is placed close to the painted surface, and, by raising or lowering the tripod, the microscope can be placed in front of any spot it is desired to inspect. By regulating the coarse adjustment, the microscope is focused on the painted surface in such a way that any checking, cracking, paint coat abrasions, or other disturbing influences, even of the slightest degree, are promptly brought to the eye of the observer. The tube-camera apparatus is then placed directly over the eyepiece of the microscope and exposure is made by lifting the shutter-cap for twenty or thirty seconds, according to light conditions, giving an excellent detail photograph.

The tube camera is made of a metal tube 1½ inches in diameter, into which is placed a lens and shutter fixed to the ordinary bulb apparatus for making an exposure. On the rear end of this tube is placed a disk of metal into which is fitted a block of wood having a central annular opening the size of the tube. On the back of the block is firmly set and screwed into position a film pack, such as is used for the ordinary photographic camera.

Figs. 11, 12, and 13 show photomicrographs made with this apparatus.

# EXPLOSIVES.

BY

F. H. GUNSOLUS,

Manager, Technical Division, E. I. du Pont de Nemours Powder Co., Wilmington, Del.

THIS subject of *Explosives* is one in which we are all rightly and justly interested and one which the majority of consumers are to-day studying as hard and thoroughly as the manufacturer, both from a humanitarian and economic standpoint; or first, to produce the safest for use, at the same time protecting the lives of the users, and second, to supply the best at minimum cost. The consumer is making it a study with the idea of determining what kind of explosive and which explosive is better adapted for the work in hand. The manufacturer studies the subject with the idea of supplying that explosive which will fill the various conditions and demands not only for the present time but also future demands.

From the time of the invention of gunpowder, or approximately in 1250, the study of explosives has been the problem for generations. With the new kinds of High Explosives, "Permissible" Explosives, Sporting Powders and Detonating Agents, the problem is one of greater moment and continues to be studied with increased care, and by a larger number of expert chemists. Perhaps a short historical retrospect will be very useful in order to fully appreciate this fact.

Gunpowder was known in a crude form by the Chinese for many centuries, but the earliest date of which there is record and which can be considered authentic in any way is 1264, when Roger Bacon made known the results of his tests. I believe, however, that the Western World only used this gunpowder for throwing projectiles. Not until 1629 was gunpowder used as a blasting agent, at which time Casper Weindl invented the use of gunpowder for blasting purposes. A demonstration was made at Schemnitz in Hungary, where it was shown conclusively that its use would materially aid in mining and quarrying operations. Until the beginning of the Nineteenth Century, however, no other explosive was introduced into practice with success. In

1788 Bertholet and Lovoisier tried the effect of adding potassium chlorate, and in 1861 Designolle made a powder from potassium picrate and saltpetre but without much success. In 1846 Schoenbein invented gun-cotton and in 1847 Sobero discovered nitroglycerin. The Austrian Government, which was the only one to try gun-cotton in guns, stopped the experiment abruptly in 1867, due to their having an explosion in the magazines at Hirtenberg. Not until 1863 was nitroglycerin available for general use owing to its extreme sensitiveness and to the inconvenience of handling it in its liquid state. Alfred Nobel, the great Swedish chemist, at this time found by using infusorial earth, known as Kieselguhr, as an absorbent for the nitroglycerin, it would overcome these objections to a large extent, and in 1867 he introduced this mixture under the name of dynamite. About this time the success of dynamite was assured by the discovery of the detonating effect of fulminate of mercury in the dynamite by Brown, a chemist in the English War Office. Gelatin dynamite was next produced when Alfred Nobel discovered that nitro-cotton was easily dissolved in nitroglycerin, forming an explosive gelatinous mass which he called blasting gelatin.

Such was practically the state of affairs as concerns explosives up to the year 1886. About this time it was recognized that most explosions in coal mines were due to the ignition of fire-damp by the firing of shots, and it was also recognized that it would be possible to produce explosives which could be used in coal mines and which would considerably reduce this danger.

From 1886 the strides made in the investigations, inventions and productions of different kinds of explosives have been very rapid. In fact, all explosive manufacturers produce two or three of the following kinds of explosives: Straight Nitroglycerin Dynamites, Gelatin Dynamites, Ammonia Dynamites, "Permissible" Explosives, Low-freezing Dynamites, Non-freezing Dynamites and Detonators of different varieties. It is left, however, to the largest manufacturers of explosives to produce all of the different kinds just mentioned.

According to the Standard Dictionary, "an explosive is any substance that may cause an explosion by its sudden combustion or decomposition." A distinction, however, should be made be-

tween explosives in general and those which are applicable to blasting purposes: a mixture of oxygen and hydrogen gases, or of fire-damp and air, or coal dust, or flour dust and air, etc., may be termed explosive, as when mixed in the proper proportion they may be exploded by a spark, flame, or by having the temperature raised by any other means.

Another very good definition of an explosive is, "Such a substance as can in an extremely short time and in a small space develop a very large amount of heat and gas exerting enormous pressure on the surrounding bodies, and is able by the expansion of highly heated gases to perform considerable work."

Some of the important qualifications of an explosive for blasting purposes are the following:

1. Sufficient stability.
2. Difficulty of detonation by mechanical shock, that is, not too sensitive.
3. Handy form.
4. Absence of injurious effect on the health of those using it.
5. Sufficient strength of action.
6. Sufficient density.
7. Comparative "flamelessness" and low heat of detonation for coal mining.

Explosives may be divided into two general classes:

1. *Low* explosives or direct exploding materials, such as blasting powder.
2. *High* explosives or indirect exploding materials, such as dynamite, gun-cotton, gelatin dynamite, ammonium nitrate, picric acid, etc.

By direct exploding materials are meant those which can be made to develop their force by direct means, such as ignition; whereas the indirect exploding materials require an intermediate agent to develop their full force, such as a blasting cap or electric fuze.

In the case of a low explosive, such as blasting powder, the force is developed by first burning some of the powder, the fire being transmitted from grain to grain, a certain amount of pressure and heat are developed, when the whole amount of powder is brought into sudden decomposition. This fact is readily shown by burning a small quantity of blasting powder unconfined, and then burning it confined, the pressure being an

important factor in bringing about the explosion of blasting powder. The finer the grain of the powder the greater proportionately is the amount of burning surface, and consequently, the quicker the complete transformation of the solid into the gases.

To the high explosive class belong all those explosives commonly known as dynamite, and which or may not have nitroglycerin as the explosive basis of the substances, such as: ordinary nitroglycerin dynamite, the ammonium-nitroglycerin compounds, gelatin dynamite, low-freezing dynamite, and the Judson powders. To this class belong all of the "Permissible" Explosives.

Whereas a perfect explosion of a low explosive results from burning, a perfect explosion of a high explosive is the result of the detonation of the explosive. This may be considered the result of a certain kind of shock causing the instantaneous destruction of the very delicately balanced forces which preserve the chemical and physical equilibrium of the explosive compound.

Defective blasting caps and electric fuzes are often causes of imperfect explosions of high explosives. Another cause, and one of frequent occurrence, is where dynamite is loaded in the same bore-hole with blasting powder without a detonator, the blasting powder being fired by the use of a squib or safety fuse. Another cause is where the fuse is laced through the cartridges of dynamite, which is very apt to set the dynamite on fire.

Before the sale of an explosive is undertaken those who manufacture and sell explosives should make such tests as will determine the characteristics of that particular explosive. Some of these points to be determined about any explosive are:

1. Sensitiveness.
2. Comparative strength.
3. Waterproof qualities.
4. Effects of temperature on the explosive.
5. Nature of gases resulting from detonation.
6. Velocity of detonation—that is *quickness*.
7. Height and duration of flame.
8. Temperature of detonation.
9. Heat of detonation.

There are many tests which have been devised and have been and are used to determine these various characteristics of

explosives as far as is possible before the explosive is taken into actual work in a quarry or mine. Only those in the explosive business seem to fully realize the difficulties in the way of a proper comparison of the value of two or more explosives. All of the points which I have just mentioned have their material effect on the value of an explosive, and much can be, and is, learned by study of an explosive at the laboratory, but the actual use of an explosive in practical work is necessary before a definite knowledge of the explosive can be obtained.

In this connection there is a point to which I wish to call your particular attention, and that is to the fact that the strength of a high explosive does not entirely depend upon the percentage of nitroglycerin in the explosive. Suppose you were making a test of two explosives, each containing the same percentage of nitroglycerin. One of these explosives may be found to be very much stronger than the other, depending entirely on the other components of the explosive. This method of grading explosives by the percentage of nitroglycerin contents is still in general use and is very unfortunate both for the consumer and the reliable manufacturer of explosives. The consumer desires an explosive having the proper strength and action to do the work he has to do, without regard of the percentage of nitroglycerin in the explosive.

In the manufacture of explosives very careful attention is given to the method of manufacture. The purity of the raw materials, the intimate mixing of the ingredients, cartridge-making and packing are all essential points to be thoroughly studied in order to produce the best explosives.

Since 1886, in England and on the continent of Europe a study has been and is being made to-day of explosives suitable for use in gaseous and dusty coal mines. As a result of these investigations many explosives are manufactured for this class of work more suitable and which can be used with more comparative safety than blasting powder or dynamite. In the United States this is a newer problem, and yet according to Explosive Circular No. 3 issued by the United States Geological Survey of the Department of the Interior, on May 16, 1910, there are manufactured forty-five "Permissible" Explosives suitable for use in gaseous or dusty coal mines.

Where large quantities of fire-damp are found, it is ex-

tremely dangerous to use either blasting powder or ordinary dynamite for *this* reason. Blasting powder produces a very long flame of considerable duration and ordinary dynamite produces a very hot flame when exploded. Because of this and the explosive character of a mixture of fire-damp and air, or coal dust and air, or of all three of these occurring in coal mines, demands are made for the development of explosives which are not liable in their use to cause an explosion of any of these mixtures.

From laboratory tests it has been determined that certain gaseous mixtures require certain temperatures to ignite them. It has been found with considerable accuracy that fire-damp mixtures ignite at a temperature in the neighborhood of 650 degrees C., or 1202 degrees F. It is also necessary to heat the fire-damp mixtures up to the ignition point during a certain length of time. Consequently, the explosion of fire-damp depends on at least two factors, namely, *time* and *temperature*.

To determine the relative safety of explosives, the United States, as well as other countries, have established experimental stations. The apparatus used consists of an artificially constructed tunnel or gallery which can be filled with fire-damp and air, or other explosive gas or coal-dust mixture, and into which various sized charges of explosives can be fired from a mortar with or without tamping. The first fact established was that no explosive is absolutely safe, as all will ignite fire-damp when the charge per bore hole is sufficiently large, which is true even where the explosion temperature of an explosive is below 2000 degrees C., or 3632 degrees F.

Thus far we have dwelt only on the *temperature of detonation of explosives*, but after careful study of this subject it has been found that other factors in connection with the charge must be considered. These are the *rate* or *velocity of detonation*, the *length* and *duration of the flame*, the *heat of detonation* or the *quantity of heat produced*, the "*after flame*" ratio, or the relation between the rate of detonation and the duration of the flame, etc. All of these qualities have their effect on the safety of explosives in fire-damp, it having been shown that the lower they are, the safer the explosives. However, no limit can be placed on any of them, as excess in any other may counter-balance it. This point has been proven in the case of blasting powder, which

possesses all the necessary qualities for a safe explosive except the duration of the flame, which alone makes it very unsafe.

In looking over the field for the uses of explosives to-day, we find this list to be of much greater length than only a few years back. At one time we believed that explosives could be used only in quarries, mines of all kinds and railroad construction work. To-day we find that explosives are used in blasting stumps, boulders, tearing down buildings, breaking up hard pan and hard sub-soil, breaking up boilers and scrap iron, digging drainage ditches, breaking up log jams and ice jams, planting orchards and many other classes of work.

The E. I. du Pont de Nemours Powder Company of Wilmington, Delaware, are considered the largest manufacturers of explosives in this country. They manufacture all the different kinds of explosives for use in different kinds of work and have the largest force of expert chemists to carefully and thoroughly study the manufacture of explosives. They also maintain a Technical Division having a large field force to assist, wherever requested, in the better use of explosives in actual work.

All of the dynamites mentioned in this article are packed in cartridge form, the standard size of cartridges ranging from ⅞ in. x 8 in. to 2 in. x 18 in., depending, of course, upon the kinds of explosives packed. As a general rule, they are packed in two sized cases, viz., 25-lb. cases and 50-lb. cases. The cases are made of one-half-inch lumber, lined with paper and a small amount of sawdust sprinkled in the bottom of each case according to regulations established by the Bureau for the Safe Transportation of Explosives.

Nearly all kinds of dynamite freeze at temperatures between 45° F. and 50° F. and they should be thoroughly thawed before using in order to obtain the full explosive effect. The low-freezing explosives, however, do not freeze much above the freezing temperature of water, yet these explosives should be thoroughly thawed when the temperature reaches the freezing point. The non-freezing explosives are, as their name suggests, truly non-freezing. As a general rule the "Permissible" Explosives used in the United States should be thawed before using if the temperature is below 50° F.

The thawing of dynamite is the cause of much loss of life, generally due to the fact that it is not given proper attention, as

many of the methods used are very crude. Too great care cannot be taken in the thawing of explosives, and it would be well for consumers of explosives to consult very freely with manufacturers on this important question.

In detonating dynamite, two methods are generally used; one by means of electricity and the other by use of safety fuse and blasting caps. Of these two methods the one most strongly recommended by explosive manufacturers for nearly all kinds of blasting is that by electricity, as it is the most effective, economical and safe system that can be used. This is especially true in coal mines, as when using safety fuze and blasting caps, the gas is apt to be ignited while lighting the fuse or by the spitting out of the fuse, while there is no danger in this respect when electricity is used.

Another very vital point to be considered in the use of explosives is the tamping material and the method of tamping the charge in the bore-holes. The best material to use is damp clay, for the reasons that it contains no gritty matter which will damage the fuze or electric fuze wires in tamping, and also it will pack well in the bore-hole and thus leave no air spaces. No inflammable material should ever be used. In tamping, the explosive should be well confined to obtain its maximum efficiency, and to insure the maximum resistance against the pressure of the gases of explosion.

Since 1886 as important results have been obtained in the manufacture, handling, storage and use of explosives as in the whole of the previous years. This is no doubt due to the enormous amount of scientific research and experiment devoted by manufacturers to the study of such questions and also demands made on manufacturers for different kinds of explosives. To-day every up-to-date manufacturer recognizes that only by the best scientific knowledge can he effect improvement or keep in line with modern developments of the industry.

# FRANKLIN INSTITUTE

## CHARTER AND BY-LAWS

### The Franklin Institute

OF THE STATE OF PENNSYLVANIA FOR THE PROMOTION OF THE MECHANIC ARTS.

An Act to amend and alter the Act incorporating the Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts.

WHEREAS, The Act approved March thirtieth, one thousand eight hundred and twenty-four, incorporating the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, has been found insufficient and inconvenient for accomplishing the objects of said corporation, and the said corporation has applied for alteration and amendment thereof.

SECTION 1. Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania, in General Assembly met, and it is hereby enacted by the authority of the same, that the present members of said corporation, and all such persons as may hereafter become members thereof, shall be, and are hereby created, a body politic and corporate by the name of the "FRANKLIN INSTITUTE OF THE STATE OF PENNSYLVANIA FOR THE PROMOTION OF THE MECHANIC ARTS," and shall have perpetual succession, be able to sue and be sued, to plead and be impleaded, to have and use a common seal, and the same to break, alter and renew at pleasure, and shall be able to take, hold, purchase and enjoy such real and other estates of any nature or kind whatsoever as they may obtain by purchase, devise, bequest or gift, and the same at their pleasure to sell, lease, mortgage, pledge, encumber, or dispose of as they may deem proper or convenient for promoting the objects of the said corporation; and the said corporation shall have the like power over any real estate or other estates now owned or held by them; *provided*, that the clear yearly value of the real estate at any time held by them shall not exceed ten thousand dollars.

SEC. 2. That it shall be lawful for the said corporation to raise funds for the payment of its present indebtedness, and for all other purposes of the said corporation, to create and sell such number of shares of stock, at ten dollars each, as may be deemed proper to represent the estates of the said corporation, and the certificates of such stock shall be in such form, be transferable in such manner, subject to such payments, and entitle the holder thereof to such privileges, as the said corporation may, by its By-Laws in reference to such stock, grant and direct.

SEC. 3. The object of the said corporation shall be the promotion and encouragement of manufactures and the mechanical and useful arts, by the establishment of lectures on the sciences connected with them, by the formation of cabinets of models, minerals, machines, materials and products, by exhibitions and premiums, by a library and by all such measures as they may judge expedient.

SEC. 4. The members of the said corporation shall consist of manufacturers, mechanics, artisans, and persons friendly to the mechanic arts, and of such stockholders in said corporation as may, by the By-Laws, be entitled to the privileges of members; and every member shall pay such sum for an annual or life subscription as the By-Laws of said corporation may require; and honorary and corresponding members may be elected at such times, and in such a way, and with such privileges as said corporation may deem expedient.

SEC. 5. The said corporation shall be managed in such way, and by such number of officers, managers and other persons as the By-Laws may prescribe; and the powers and functions of such officers, managers or other persons, the rights and duties of members, the manner of their election, and the causes which may justify their expulsion or suspension, and all other con-

cerns of the said corporation, shall be fixed and regulated by its By-Laws, which By-Laws shall be adopted by said corporation at the first monthly meeting after the acceptance of this amended Charter, and said By-Laws shall be altered and amended only in the manner provided in said By-Laws as then adopted.

SEC. 6. So much of the Act to which this is a supplement as is inconsistent herewith is repealed.

OFFICE OF THE SECRETARY OF THE COMMONWEALTH OF PENNSYLVANIA,

APRIL 25th, 1864.

I certify that the foregoing bill passed both branches of the Legislature, and received the signature of the Governor on this day. As witness my hand the day and the year above written.

(Signed.) ELI SLIFER,
*Secretary of the Commonwealth.*

## BY-LAWS

ARTICLE I.—*Trustees.*

SECTION 1. All Real and Personal Estate of the Institute which may hereafter be acquired by voluntary subscription or devise, bequest, donation, or in any way other than through its own earnings or by investment of its own funds, saving where the donors shall expressly provide to the contrary, shall be taken as acquired upon the condition that the same shall be vested in a Board of Trustees, who shall be appointed in the manner hereinafter indicated. Unless the title to such property shall be directly vested in said Board of Trustees by the donors, the Institute, by deed attested by the President and Secretary, which they are hereby authorized to execute and deliver, shall forthwith convey the same to said Trustees, who shall hold it in trust for the purposes specifically designated by the donors; or, if there shall be no specific designation, for the benefit of the Institute in the way and manner hereinafter provided, so that the same shall not, in any event, be liable for the debts of the Institute.

SEC. 2. Said Board of Trustees shall be composed of seven (7) members, who shall be elected by the Board of Managers from nominations made at a stated meeting of the Board at least one month prior to the election. Vacancies in the Board of Trustees shall be filled in the same manner.

The remaining members of the Board of Trustees, whenever at any time it shall be deemed necessary so to do, shall have power to assign and convey the property held by them, so as to vest the title thereto in themselves and their successors.

SEC. 3. Said Trustees shall have full power and authority, from time to time, to assign, sell and dispose of any property, real and personal, by them held, unless there shall be some direction by the donors to the contrary, and shall have power to convey the same without purchasers being obliged to see to the application of the purchase moneys, when authorized so to do by a vote of two-thirds (2-3) of the members present at any regular or special meeting of the Board of Managers, *provided*, that they shall not be obliged to sell or convey unless a majority of their own Board shall also approve.

SEC. 4. Said Trustees shall not be confined to legal investments, but shall have full power to invest in any real property, improvements and alterations, and in any securities, other than shares of stock, or unusual personal obligations, which to them may seem advisable.

SEC. 5. Said Trustees shall have power to appoint agents to act for them, and for the acts of such agents they shall not be personally responsible where they have exercised ordinary prudence in selecting them.

SEC. 6. Said Trustees shall have power to carry into effect any special trusts upon which any property may be held by them. They shall pay out all necessary and proper costs, charges and expenses, and from time to time shall pay over the net income to the Board of Managers, to be applied by them, to the uses of the Institute in accordance with the terms of the trusts from which the income is derived.

The principal and interest of all trust funds shall not be liable for debts of the Institute but shall be devoted to its continuance and preservation.

SEC. 7. At the annual meeting of the Board of Managers in each year, said Board of Trustees shall present a report of their proceedings and a detailed statement of their receipts and expenditures for the year. An approval of such account shall be final and conclusive, and shall bar anv right to demand any other or further accounting.

SEC. 8. The Board of Trustees, at a meeting of the members of the Institute, called after three (3) months' special notice, at which the holders of nine-tenths (9-10) of the whole outstanding shares of stock shall vote affirmatively, may convey all property, real and personal, in them vested, to the Institute, free and clear of all trusts; *provided*, that there be no specific trusts violated by such conveyance, and that all the members of said Board, as the same shall then be constituted, shall approve of such conveyance.

ARTICLE II.—*Stock.*

SECTION 1. The Real and Personal Estates of the Institute as held upon the First day of January, One Thousand Eight Hundred and Eighty-one, shall be valued at One Hundred Thousand Dollars, and shall be represented by Ten Thousand Shares of Stock of the par value of Ten Dollars each. Said shares shall be divided into two classes, viz.:—

*First Class.*—Shares not registered for use: on which no annual payment shall be charged or collected, and the holders thereof shall not have the privileges of members of the Institute, but may, if of legal age, vote at any annual election for officers, managers and auditors, upon the payment of One Dollar upon each share of stock on which they may desire to vote; *provided, however*, such shares have been held by the same person at least three months before such election.

Shares of the First Class may be converted into shares of the Second Class at the pleasure of the owners, provided the transfer be approved by the Board of Managers; but, when once so converted, they shall always continue in the Second Class.

*Second Class.*—Shares registered for use: on which Twelve Dollars per annum shall be due and payable from resident members in advance on the first day of October in each year, except as hereinafter provided.

Non-resident holders of Second Class Stock shall pay an annual fee of Five Dollars.

SEC. 2. The holders of Second Class stock shall be entitled to the use of the library, lectures and reading-room; and, if of legal age, to all other privileges of membership in the Institute, so long as they make the annual payment in advance; and shall, on the payment of One Dollar therefor, be entitled to a Certificate of Membership.

SEC. 3. If the annual dues for two successive years remain unpaid at the expiration of two and a-half years on any share of stock of the Second Class, such share shall then become forfeited to the Institute; but such forfeiture may be remitted by a unanimous vote of the Board of Managers.

SEC. 4. Stock of the Second Class may be held in trust for persons not of legal age, and shall be liable to the payment of only one-half the annual fees due upon stock of Second Class held by persons of legal age: *provided*, that when such minors arrive at legal age, new certificates, subject to the full annual contribution, shall issue on payment of the customary fee.

SEC. 5. Certificates for the First Class stock may be issued for any number of shares in a single certificate; but every certificate for the Second Class shall be for one share only.

SEC. 6. No share of stock in the Second Class shall be transferred until all arrearages and fines are paid, and all books and tickets returned, and the transfer approved by the Board of Managers.

SEC. 7. All certificates of stock shall be signed by the President and Secretary; shall be issued by the Actuary, and shall be transferable only on the books of the Institute by the owner, or his legal representative, on the surrender of the old certificate, and of a fee of twenty-five cents for each certificate.

SEC. 8. All subscriptions to stock shall be approved by the Board of Managers before the certificate can be issued.

SEC. 9. The shares of stock obtained by the Institute by legacies, donations or forfeiture, shall at once be cancelled.

ARTICLE III.—*Members.*

SECTION 1. The members of the Institute shall consist of manufacturers, mechanics, artisans, and persons friendly to the mechanic arts, and they may be either annual contributors, associate members, life members, permanent members, holders of Second Class stock, honorary or corresponding members.

SEC. 2. The privileges of membership, other than associate membership, in the Institute shall extend only to persons of legal age who are not in arrears and who shall have signed the Charter and By-Laws.

SEC. 3. Annual contributors shall pay yearly dues of Fifteen Dollars; shall be entitled to all of the privileges of the Institute, and shall be eligible to any office or to membership upon any committee.

SEC. 4. Non-resident annual contributors shall pay an entrance fee of Five Dollars and annual dues of Five Dollars.

SEC. 5. Associate members shall be over seventeen and under twenty-five years of age. They shall have the right to attend all meetings of the Institute, use the library, receive the Journal and serve upon committees, but they shall not have the right to vote or to hold office. They shall pay annual dues of Five Dollars. The term of an associate member shall be limited by the age of twenty-five years after which he shall become an annual contributor with the dues and privileges of that class and he shall be duly notified of the transfer.

SEC. 6. Annual contributors whether resident, non-resident or associate members shall be elected by the Board of Managers.

SEC. 7. Honorary and Corresponding Members shall be nominated by the Board of Managers, and shall require for their election four-fifths of the votes of the members present at any meeting of the Institute at which their nomination may be acted upon. They shall pay no dues.

SEC. 8. Life members, whose membership shall not be transferable, may be elected by the Board of Managers upon the payment of Two Hundred Dollars in any one year.

Non-resident Life members may be elected in the same way upon payment of Seventy-five Dollars in any one year.

SEC 9. A permanent membership, which may be transferred by will or otherwise, subject to the approval of the Board of Managers, may be granted by the Board of Managers to any one who shall contribute to the Institute for that purpose the sum of One Thousand Dollars in any one year.

SEC. 10. Non-resident members shall be those who reside permanently at a distance not less than twenty-five miles from Philadelphia. Transfers of membership from the resident to non-resident class may be granted by the Board of Managers at its discretion in cases of temporary absence of a member from the city for a period of not less than one year.

SEC. 11. Members shall be entitled to a Certificate of Membership on payment of One Dollar.

SEC. 12. Resignations of membership shall be made to the Board of Managers in writing, but shall not be accepted until all dues, fines, and arrears of dues and current dues at the annual rate up to the date of resignation, shall have been paid, and books and tickets returned.

ARTICLE IV.—*Payments of Dues.*

SEC. 1. The annual payment of fees for membership shall be due and payable on the first of October in each year, in advance; but all members elected after the 31st of January in each year shall pay, in advance, the proportionate amount of the annual dues for the remaining months of the Institute year.

SEC. 2. Any member whose dues are more than three months in arrears shall be notified by the Actuary. Should such dues not be paid when they become six months in arrears, the privileges of membership shall by that fact be suspended. When nine months in arrears such member shall be again notified, and if such dues become one year in arrears, the said member shall by that fact forfeit all connection with

the Institute. The Board of Managers, however, may, for cause by it deemed sufficient, extend the time for payment and for the application of these penalties.

The Board of Managers may, for sufficient cause, temporarily excuse from payment of annual dues any member who from ill health, advanced age, or other good reason assigned, is unable to pay such dues; and the Board may remit the whole or part of dues in arrears or accept in lieu thereof service or material contributed to the Institute.

SEC. 3. Every person admitted to membership in the Institute shall be considered as liable for the payment of dues until he shall have resigned, been dropped or have been relieved therefrom by the Board of Managers.

SEC. 4. The annual dues from contributing members may be applied to the current expenses of the Institute, but all moneys received from life and permanent membership shall be vested in the Board of Trustees, the income therefrom only to be applied to the maintenance fund.

ARTICLE V.—*Officers.*

The officers shall be a President, three Vice-Presidents, a Secretary, a Treasurer, and twenty-five Managers. A majority of the Managers shall be persons directly interested in industrial pursuits.

ARTICLE VI.—*Election of Officers.*

SECTION 1. An election for officers shall be held on the third Wednesday in January in each year. At this election the President and the Treasurer shall be elected to serve one year, and one Vice-President, and eight Managers, shall be elected to serve for three years; *provided*, that the officers now elected or who may hereafter be elected, shall continue to serve until their successors be elected.

One Manager, to be known as the Alumni Manager, shall be elected in January of every third year, beginning in the year 1910, by the Alumni Association of the Institute, to serve for three years. A vacancy in this position shall be filled by election in the same manner for the unexpired term.

The Secretary shall be elected by the Board of Managers at their first stated meeting after the annual election each year.

SEC. 2. All elections for officers of the Institute shall be by letter ballot, and no vote may be cast by proxy, nor received from a member in arrears.

SEC. 3. Nominations for the annual election for officers shall be presented in writing at the stated meeting in the month of December. Each nomination paper must be signed by at least two members in good standing, who shall certify that the candidate will serve if elected. After the nominations are closed, the President shall appoint three members, who are neither officers nor nominees, to act as tellers of the election. The list of nominees shall promptly be posted at the Institute and incorporated (with directions for voting) in a ballot to be sent to each member by the Secretary at least one week before the date of the election. Each ballot shall be accompanied by a return envelope addressed "To the Tellers of Election," and provided with a space for the signature of the member voting.

SEC. 4. On the date of the annual election, and at an hour previously designated by their chairman, the tellers shall meet at the Institute and shall count all legal votes that have been received by mail or placed in the ballot box before 8 o'clock P. M.; and when the count is completed they shall report to the annual meeting of the Institute the total number of ballots cast, together with the number of votes received by each candidate. Thereupon the presiding officer shall announce the names of the candidates who received the plurality of votes for each office, and shall declare them elected officers of the Institute for the ensuing terms.

ARTICLE VII.—*President.*

It shall be the duty of the President, or, in his absence, of one of the Vice-Presidents, in order of seniority of election, or, in their absence, of a President to be chosen *pro tempore*, to preside at all meetings of the Institute and of the Board of Managers.

ARTICLE VIII.—*Secretary.*

SECTION 1. The Secretary of the Institute shall be a person of scientific attainments. He shall receive such salary as may be fixed by the Board of Managers.

SEC. 2. He shall have general charge and supervision, subject to the Board of Managers, of all the work of the Institute, and of its library, museum, laboratories, and property in general.

SEC. 3. He shall keep the minutes of all meetings of the Institute; and shall perform all the duties usually pertaining to the office of secretary.

SEC. 4. He shall be *ex officio* a member of the Board of Managers and of all standing committees of the Institute.

SEC. 5. As *ex officio* Secretary of the Committee on Science and the Arts he shall attend all meetings of that Committee and keep the minutes thereof. He shall also attend meetings of sub-committees at which his attendance has been requested, and when desired shall aid sub-committees in making searches and in the examination of authorities, documents, apparatus, etc.

Two weeks before each stated meeting of the Committee he shall report to its Chairman the status of all investigations pending before the sub-committees.

He shall also perform any other duty that may tend to advance the work of the Committee.

With the approval of the Board of Managers he may appoint an assistant to perform some, or all of his duties as Secretary of this Committee.

ARTICLE IX.—*Treasurer.*

It shall be the duty of the Treasurer to receive from the Board of Trustees all funds, which they may pay over to the Board of Managers in accordance with Section 6 of Article I. He shall also receive all moneys collected for the Institute by the Actuary. He shall deposit all moneys received, in the name of the corporation, in such institution as the Board of Managers may direct. He shall make no payments without written vouchers from the Board of Managers. He shall keep accurate accounts of the income and disbursements of the Institute, exhibit an accurate statement of his receipts and payments at each stated meeting of the Board of Managers, and of the condition of the finances of the Institute whenever called on by them, and shall make an annual statement thereof at the annual meeting of the Institute. He shall give bonds to an amount fixed by the Board of Managers for the faithful performance of his trust. In case of a vacancy in the office of treasurer, it shall be the duty of the Board of Managers to appoint a person to perform the duties of the position *pro tempore.*

ARTICLE X.—*Board of Managers.*

SECTION 1. The Board of Managers shall consist of 25 members elected as provided in Article VI; all officers of the Institute, *ex officio*, except the Trustees; and the Chairman of the Committee on Science and the Arts, *ex officio.*

The Board of Managers shall have entire charge and control of the current receipts and expenditures of the Institute, and of all its business affairs not specially reserved to the Board of Trustees, and shall have authority to do all acts not inconsistent with the rights and duties of the Trustees which may in their judgment advance the interests of the Institute.

They shall have authority, by exchange, sale or otherwise, to add to or subtract from the collections of books, furniture and apparatus, in such manner, however, that the aggregate value of the same to the Institute, at any time, may not be impaired.

They shall have authority to elect members of the Institute, except Honorary and Corresponding Members, who shall be elected by the Institute.

SEC. 2. They shall keep regular minutes of their proceedings, which shall be open at all times to inspection by members of the Institute.

SEC. 3. They shall present at the annual meeting of the Institute, a report of their proceedings and of the condition of the affairs of the Institute.

SEC. 4. They shall hold stated meetings once in each month. They shall elect their own officers, except the chairman, who shall be the President of the Institute, or in his absence, as provided for in Article VII, and shall be at liberty to make by-laws for their own regulation not inconsistent with

the Charter, or with the By-Laws of the Institute. Seven of their members shall constitute a quorum.

SEC. 5. All vacancies in the Board of Managers shall be filled by an election at the next stated meeting of the Institute.

ARTICLE XI.—*Audits.*

The accounts of the Treasurer and Board of Trustees shall be audited at least once a year by certified public accountants, who shall report to the Board of Managers.

ARTICLE XII.—*Committees of the Institute.*

SECTION 1. There shall be the following Standing Committees, each to consist of ten members, to be appointed by the President, at the first meeting after the annual election, who may be aided in his choice by nominations made at the annual meeting. All members notified of their appointment to any committee, if they do not decline before the next stated meeting, shall be considered members thereof:—

1. On the Library.
2. On the Museum.
3. On Meetings.

SEC. 2. There shall be a Committee on Science and the Arts, consisting of sixty members of the Institute, who shall pledge themselves by their acceptance of membership to perform such duties as may devolve upon them and to sustain by their labors the scientific character of the Institute.

They shall be elected by the Board of Managers at its stated meeting on the fourth Wednesday of January, twenty members being elected each year to serve for three years.

The Secretary shall report to the Board of Managers at said meeting the number of vacancies on the Committee from any cause, and the names of those whose terms expire that year, together with the record of their attendance at meetings of the Committee, and a brief summary of their participation in the work of the Committee and its sub-committees. Vacancies occurring during any year may be filled by the Committee itself by election of members to serve until the following January.

Within one month after the Annual Election, the Committee shall hold a meeting at which it shall elect a Chairman for the current year.

It shall be the duty of the Committee to investigate and report upon any subject referred to it by a vote of the Institute, or any Section thereof, and at its discretion to investigate other subjects on application.

Applications for the examination of any subject shall be made to the Committee, either by recommendation of the Institute, or any Section thereof, or by requests from inventors or others, under the regulations of the Committee.

It shall also be the duty of the Committee to make or recommend the award of medals and other forms of recognition established by, or in charge of, the Institute.

Sub-committees to examine any subject shall be appointed by the Chairman of the General Committee from its membership, but they may include a minority of persons who are not members of the General Committee or of the Institute, but whose expert services are desired in the examination.

Reports of sub-committees shall be made to the General Committee in writing.

Final action on a report conferring or recommending an award shall not be taken by the General Committee except at the second of two successive stated meetings at which it has been read and been open for discussion and amendment.

A quorum for final action upon a report conferring or recommending an award shall consist of not less than fifteen members, and when such report is adopted it shall be accepted as the decision of the Institute.

Reports when issued after final adoption shall set forth that they are the action of the Franklin Institute by its Committee on Science and the Arts. They shall be signed by the President and the Secretary of the Institute and by the Chairman of the Committee; and the seal of the Institute shall be affixed thereto. The Committee may provide that such reports shall also be signed by the members of the respective sub-committees who made the investigations and prepared the reports.

The Chairman of the Committee shall submit to the stated meetings of the Board of Managers in October, Decem-

ber, February, April, and June of each year, a report of the number of investigations pending before the Committee, the number disposed of since the last report, with the action taken or award made in each case, and the number and nature of new investigations undertaken since the last report, and such other information as to the work of the Committee as the Board of Managers may require.

He shall also report to the stated meetings of the Institute such recent action of the Committee as he may deem of interest.

At the request of the Committee on Publications, and to make an adopted report more suitable for the use in the Journal of the Institute, the subcommittee that prepared the report shall have authority to amplify or abridge it without in any way changing its meaning or recommendation for award; but the fact of such modification must be stated as a note at the beginning of its publication in the Journal.

SEC. 3. Each committee named in the first and second sections shall choose a chairman at its first meeting after its appointment.

Record of their proceedings shall be kept by the Secretary. They shall report to the Institute, and when required to the Board of Managers.

They shall be governed by such rules, not inconsistent with these By-Laws, as may be adopted by them respectively.

The Committees on the Library, on Meetings, and on Science and the Arts, shall meet at least once in each month, except in July and August.

SEC. 4. No bills for expenses incurred by committees shall be paid unless approved by the Committees which incurred them.

ARTICLE XIII.—*Meetings.*

SECTION 1. The Institute shall hold stated meetings on the third Wednesday of each month, except in July and August. That on the third Wednesday in January of each year shall be the annual meeting.

SEC. 2. Special meetings shall be called by order of the President, upon request of the Board of Managers, or the written application of twelve members of the Institute. Fifteen members shall constitute a quorum.

ARTICLE XIV.—*Order of Business.*

SECTION 1. The stated meetings of the Institute shall be held at the hour of 8 o'clock P. M.

SEC. 2. The order shall be as follows:

1. Reading of the Minutes.
2. Reports from the Board of Managers.
3. Reports from the Standing Committees, etc.
   (1). On the Library.
   (2). On the Museum.
   (3). On Meetings.
   (4). On Science and the Arts.
4. Reports from Special Committees.
5. The paper announced for the evening.
6. The Secretary's report.
7. Deferred business.
8. Consideration of new business.

SEC. 3. At the annual meeting, the tellers' report may be received and read by the Secretary immediately after the conclusion of any number of the order of business.

SEC. 4. The order of business may be altered for any meeting by a vote of two-thirds of the members present thereat.

ARTICLE XV.—*Rules.*

The Institute, at its meetings, shall be governed by Roberts' Rules of Order.

ARTICLE XVI.—*Organization and Government of Sections.*

SECTION 1. For the promotion and encouragement of manufactures and the mechanic arts, as well as of the sciences connected with them, members of the Institute may form sections and hold meetings in such rooms as may be provided for them by the Board of Managers. These sections shall be constituted as hereinafter provided, and shall have precedence in the order of their formation.

SEC. 2. Any number of members, not less than twelve, may constitute a section.

SEC. 3. Members desiring to form a section shall make written application to that effect to the Committee on Sectional Arrangements, which committee shall report such applications to the Board of Managers.

If the application shall be approved

by the Board of Managers, the section shall be established and the names of the petitioners shall be recorded on the minutes as the founders of that section, and shall be reported by the Board of Managers to the Institute at its next meeting. Whenever the petitioners shall have organized, they shall report such organization, with the names of their officers, to the Committee on Sectional Arrangements. But if they shall fail to organize such section within six months after the date of said approval, or if an established section shall fail to make a report of its proceedings to the committee during any period of twelve months, it shall be the duty of the Committee on Sectional Arrangements to inform the Board of Managers, which may thereupon declare that such section is extinct.

SEC. 4. All members of the Institute shall have the privilege of enrolling themselves, without payment of additional fees, as members of any of the sections which are now, or which may hereafter be, established in conformity with these By-Laws, and such enrollments shall be reported from month to month to the secretaries of the sections designated; but no person shall be entitled to any of the privileges of any of the sections who has not complied with the conditions of Article III of these By-Laws.

SEC. 5. Each section shall submit to the Committee on Sectional Arrangements prior to the stated meetings of the Board of Managers in December of each year, an estimate of moneys it will require for the ensuing year, and such estimate the Committee on Sectional Arrangements shall transmit, with its recommendation, to the Board at its stated meeting in December.

SEC. 6. Each section shall elect its own officers and make its own by-laws, not inconsistent with the Charter and By-Laws of the Institute. The Institute shall not be responsible for bills contracted by any section in conformity with the conditions prescribed in Section 4 of Article XII of the By-Laws relating to committees, nor in any event for a sum greater in any one year than the amount appropriated by the Board of Managers for the service of the section for that year.

SEC. 7. All requisitions for supplies shall be made by order upon the Actuary of the Institute.

SEC. 8. The books, papers, apparatus, specimens, models and all other collections of each section, shall be the property of the Institute, held for the use of that section. Donations of objects or books to or for any section, shall be received and reported to the Committee on Sectional Arrangements, and by this committee to the Board of Managers, as donations to the Institute for the use of that section.

SEC. 9. Each section shall determine, subject to the approval of the Board of Managers, the times of its stated meetings.

SEC. 10. Papers read and lectures delivered before any section and approved by the same, shall be referred to the Committee on Publications of the Institute, and if accepted by them, shall be published in the *Journal* of the Institute.

SEC. 11. Societies now existing, or which may hereafter be founded, for the consideration of any subjects clearly within the scope of the Franklin Institute, and which societies may desire to unite with the Franklin Institute as sections, shall furnish a list of such of their members as have declared their willingness to become members of the Institute, to the Committee on Sectional Arrangements, which committee shall transmit the same, with its recommendation, to the Board of Managers.

SEC. 12. On all points not herein provided for, each section shall be governed by the Charter, By-Laws and usages of the Institute.

### ARTICLE XVII.—*Amendments.*

Proposals for amendments to these By-Laws shall be presented in writing, signed by two members in good standing, at any stated meeting of the Institute. By a majority vote of the members present at this meeting they may be considered, amended, referred, postponed, rejected, or ordered to be voted upon at the date of the next stated meeting, until which time they shall be posted at the Institute. The final vote upon amendments shall be by ballot, and if two-thirds of the votes cast are in favor of any proposed amendment, it shall be declared adopted; except that amendments to Article II, re-

lating to capital stock, must (subsequently) be ratified by a majority of the stock represented at a meeting specially called for this purpose.

## BY-LAWS OF THE BOARD OF MANAGERS

SECTION 1. *Officers.*—The President of the Institute, or, in his absence, the Vice-President, in order of seniority of election, or in the absence of both, a member elected *pro tempore*, shall preside at all meetings of the Board. Records of its proceedings shall be kept by the Actuary.

SEC. 2. *Meetings.*—The Board shall hold a meeting for the purpose of organizing, electing a Secretary, and a Committee on Science and the Arts; and appointing an Actuary, Standing Committees, etc., on the fourth Wednesday in January, and regular meetings on the second Wednesday of each month, at 3.30 o'clock P. M.

SEC. 3. Special meetings may be called by the President at his discretion, and shall be called on written request of five members of the Board. In case of his absence or refusal to act, such special meeting shall be called by the Actuary.

SEC. 4. *Actuary.*—An Actuary shall be appointed by the Board at their first meeting after the annual election. He shall keep a correct record of their proceedings; keep a roll of the members, and note their attendance thereon; give notice of all meetings of the Board, and of committees, delivered at least two days prior to the day of meeting; act as Secretary of all Standing Committees of the Board; notify all committees of the Board of their appointment, and transmit to the chairman of each all papers or documents relating to the subject to be considered or acted upon. He shall collect and receive all moneys due to the Institute, and hand them over to the Treasurer; shall act as agent of the *Journal* of the Institute, and shall transact such other business of the Institute as the Board shall direct. In all matters he shall be subject to the direction and control of the Board, and he shall receive such yearly compensation as they may determine.

SEC. 5. *Resignations.*—All resignations by members of the Board, after acceptance thereof, shall be reported to the Institute at its next stated meeting.

Members who have not attended six regular meetings prior to the stated meeting of the Institute in December, shall be reported thereat as having resigned, unless it be unanimously voted by the Board, at its stated meeting in December, that such member has been absent for sufficient reason.

SEC. 6. *Standing Committees.*—The following Standing Committees, consisting of five members each, shall be appointed by the President and approved by the Board:—

1. On Instruction. 2. On Election and Resignation of Members. 3. On Stocks and Finance. 4. On Publications. 5. On Exhibitions. 6. On Sectional Arrangements. 7. On Endowment.

It shall be the duty of these committees to keep regular minutes of their proceedings, and report monthly to the Board, and to report to the stated meeting of the Board in December an estimate of moneys they require for the service of the ensuing year.

SEC. 7. *Professorships.*—The Board may, at its discretion, establish such Professorships as may seem advisable, and on such subjects as it may designate, to serve until the next succeeding first meeting after the annual meeting.

SEC. 8. *Order of Business.*—The order at the stated meetings shall be as follows:—

1. Calling the roll.
2. Reading the minutes and acting thereon.
3. Report from Treasurer, and action on bills.
4. Reports from Standing Committees, and action thereon.
   (*a*). On Instruction.
   (*b*). On Election and Resignation of Members.
   (*c*). On Stocks and Finance.
   (*d*). On Publications.
   (*e*). On Exhibitions.
   (*f*). On Sectional Arrangements.
   (*g*). On Endowment.
5. Reports from Special Committees and action thereon.
6. Deferred Business.
7. New Business.

SEC 9. *Amendments.*—These By-Laws may be altered at any stated meeting of the Board, provided the alteration be approved by two-thirds of the members present.

# FRANKLIN INSTITUTE

## REGULATIONS OF THE COMMITTEE ON SCIENCE AND THE ARTS OF THE FRANKLIN INSTITUTE

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, May 12, 1909, and approved by the Institute at its stated meeting held December 15, 1909.

### ARTICLE I.—*Meetings.*

SECTION 1. The Committee shall hold a stated meeting at 8 o'clock P.M., on the first Wednesday of each month, excepting July and August. Special meetings may be called by the Chairman, and shall be called by him upon the written request of five members of the Committee.

SEC. 2. At all meetings of the Committee nine members shall constitute a quorum for the transaction of general business but for final action upon a report conferring or recommending an award a quorum shall consist of not less than fifteen members.

SEC. 3. At its stated meetings the Committee shall proceed in the following

*Order of Business*

1. Calling the roll.
2. Reading of the minutes of preceding meeting.
3. Reading of correspondence.
4. Report of subcommittee on Preliminary Examination.
5. Report of subcommittee on New Subjects and Publicity.
6. Consideration of reports for final action.
7. Reports of subcommittees of investigation, first reading.
8. Deferred business.
9. New business.
10. Adjournment.

SEC. 4. Members may speak twice on any question except as otherwise provided but not oftener without the consent of the Committee.

SEC. 5. There shall be no debate on points of order except on an appeal from the decision of the Chairman, or on a question referred by him to the Committee. In such cases no member shall speak more than once, unless by consent of the Committee.

### ARTICLE II.—*Chairman.*

SECTION 1. Nominations for a chairman to serve for one year shall be made at the stated meeting of the Committee in February, and the election shall be by ballot at the same meeting, when the person receiving the highest number of votes shall be declared elected. He shall immediately assume his office and shall perform its duties until his successor shall be installed. He shall not be eligible for election in successive terms.

SEC. 2. The Chairman shall appoint the members of all subcommittees, unless otherwise ordered and may serve *ex officio* on all subcommittees, except on those charged with investigations.

Whenever he shall ascertain that any member of a subcommittee fails to discharge his duties, he is empowered to substitute another member.

### ARTICLE III.—*Investigations and Reports.*

SECTION 1. By a vote of a majority of the members present at any stated meeting, it shall be competent for the Committee to investigate any subject which may be presented on the motion of a member, or by application as herein provided.

SEC. 2. Every applicant who may submit a subject to the Committee for investigation, shall be furnished by the Secretary with a copy of the rules and regulations of the Committee governing investigations.

SEC. 3. Applications for investigation of any subject shall be made to the Secretary of the Institute in writing on blank forms to be furnished by him

(substantially in the form hereto annexed and marked form "A"), and upon acceptance or rejection of the same he shall notify the applicant accordingly.

SEC. 4. There shall be a special subcommittee, to be appointed by the Chairman, and to be styled the "Subcommittee on New Subjects and Publicity;" the purpose of which shall be to keep a general observation, so far as it can, of progress made in science and the arts, and to report to the Committee subjects worthy of investigation; and also to cooperate with the Secretary in keeping the work of the Committee properly before the public. It shall report to the Committee at the stated meetings in February, April, June, September and December of each year.

SEC. 5. There shall be a special subcommittee to be appointed by the Chairman, and to be styled the "Subcommittee on Preliminary Examinations." All applications for investigation shall be at once referred by the Secretary of the Institute to this subcommittee, except in case of subjects referred to the Committee by the Institute or by any section thereof or by the subcommittee on "New Subjects and Publicity," which subject shall come directly to the Committee.

The Subcommittee on Preliminary Examinations shall meet, at least once prior to each regular meeting of the Committee, and after making a preliminary examination of the subjects of applications referred to it shall report to the committee at each regular meeting what applications in its judgment should be accepted and what declined.

SEC. 6. There shall be a special subcommittee to be appointed by the chairman with the consent and approval of the general committee and to be styled the "Subcommittee on Literature."

It shall be the duty of this subcommittee to examine carefully all papers that have been presented to the Institute and published in its JOURNAL during the current year and to report at the following January meeting to the general committee which of said papers, if any, in its judgment deserve the award of either of the following medals, viz:

*1. The Potts Gold Medal;*

*2. The Longstreth Silver Medal.*

The Committee may at its discretion, award said medals to the authors of papers and reports so recommended except that they shall not award more than one Potts medal in any one year.

The medals shall be sent to the authors to whom they are awarded, together with a certificate of their award signed by the President and Secretary of the Institute and the chairman of the committee.

If for sufficient reasons, the Committee on Literature does not recommend any or all of these awards, during any year, the award may be omitted for that year.

SEC. 7. No person shall be a member of a subcommittee of investigation who is or has been interested in the issue.

SEC. 8. A quorum for the transaction of business at any meeting of a subcommittee properly called, shall consist of any two or more members present.

SEC. 9. No applicant or other person interested in the issue of an investigation shall be present at a meeting of a subcommittee or of the general committee when a subject of invention in which he is interested shall be under discussion, except at the invitation of the subcommittee charged with the investigation; but after the report of the subcommittee has passed its first reading, he may examine it, on application to the Secretary, and may make any explanations or objections, in writing, addressed to the Chairman of the general committee; provided that such explanations or objections shall be submitted not later than the next stated meeting of the general committee.

SEC. 10. No subject or invention can be withdrawn after it has been assigned to a subcommittee for investigation without the consent of the general committee.

SEC. 11. Each subcommittee of investigation shall report its progress, and conclude with its final report, to the general committee, at intervals of not more than two consecutive stated meetings; and any subcommittee failing so to report for four consecutive meetings may be discharged from further consideration of the subject at the discretion of the chairman, who shall then appoint

a new subcommittee to continue the investigation.

SEC. 12. Subcommittees in preparing their reports shall accompany them with drawings or diagrams, whenever these will serve to illustrate the subject of their reports; and they shall be authorized, whenever they shall deem it necessary, to require applicants to furnish such drawings or diagrams as a condition precedent to such investigations and reports.

SEC. 13. Reports on all subjects must be signed by a majority of the members of the subcommittee charged with the investigation. Minority reports shall be received and by a vote of a majority of the members of the general committee may be considered.

SEC. 14. The Committee shall award the medals and other forms of recognition established by or in charge of the Institute, as directed by the By-Laws thereof.

SEC. 15. When any subcommittee of investigation deems the subject upon which it reports worthy of an award of the Elliott Cresson Medal, the Howard N. Potts Medal, the Edward Longstreth Medal of Merit, Certificate of Merit, or the John Scott Legacy Premium and Medal it shall conclude its report with a recommendation to that effect and such recommendation shall not be changed by the general committee except by a vote of two-thirds of the members present.

SEC. 16. It shall not be competent for any member of the Committee on Science and the Arts to be a competitor for any of the medals or other awards in the gift, or subject to recommendation of the said committee, unless the subject for award be referred to the Committee for examination by a vote of the Institute.

SEC. 17. No final report of a subcommittee of investigation shall be considered at any meeting of the general committee unless at least one member of the subcommittee signing the report is present.

SEC. 18. The reports of all subcommittees may be discussed and amendments proposed at the meeting of the general committee at which they are first presented, but both report and amendments shall be laid over for a second reading and final action until the next stated meeting, except that where no recommendation of an award is included in the report, it may be, by a majority vote, taken up for second reading and finally disposed of.

SEC. 19. It shall be the duty of the Secretary to certify to the applicant the action of the general committee, and to furnish to the said applicant one copy of its report within ten days after the same shall have been finally adopted, except in cases where the Committee has made or recommended an award, when the copy shall neither be furnished the applicant nor published except by title during the time in which proper objections to such award, or motion for reconsideration, may be made, but the report may be seen by any person on application to the Secretary. In default of such motion or objection, the previous action upon a report and award shall be final.

SEC. 20. A motion for the reconsideration of a report may be made not later than the next stated meeting after its adoption and may be acted upon at the next following stated meeting, when a vote of two-thirds of a quorum for final action shall be necessary to amend the report as previously adopted. A second investigation of the same subject shall not be ordered, except on a vote of two-thirds of the members present at a stated meeting.

SEC. 21. Reports when issued after final adoption shall set forth that they are the action of the Franklin Institute by its Committee on Science and the Arts. They shall bear the names of all the members of the respective subcommittees who made the investigations and signed the original reports, and shall be attested by the President and Secretary of the Institute and by the Chairman of the committee and stamped with the seal of the Institute.

SEC. 22. In all cases where awards are given for compounds, specimens thereof shall be furnished the Institute to keep in its Museum as evidence of the subject of the award.

And all other subjects investigated and for which awards are made, which

may be presented to the Institute, shall be preserved in the Museum.

ARTICLE IV.—*Amendments.*

Proposals to amend the regulations shall be made at a stated meeting in writing and signed by at least two members. They may be considered when presented, but shall not be acted upon until the next stated meeting, and shall be adopted if then agreed to by two-thirds of the members present. In all cases, notice of proposed amendments shall be sent to each member on the program for the meeting at which they may be acted upon.

*Regulations Governing Subcommittees of Investigation.*

*Appointments.*—When the personnel of a subcommittee of investigation is finally determined, a notice shall be sent to each member thereof giving the names of members of the committee and setting forth regulations governing investigations.

*Meetings.*—Meetings are to be held at the Institute when possible and all notices of meetings are to be sent from the Secretary's office.

*Information.*—When the Secretary has obtained the necessary information from the applicant, he shall notify the subcommittee who may then proceed with the investigation. When data or tests are submitted by other than the members of the subcommittee, it shall be so stated in the report.

*Reports.*—All final reports are to have a uniform beginning and ending, and are to be typewritten on official paper of the Institute.

*Signing.*—Reports must be signed by a majority of the subcommittee before they are filed with the Secretary. No member of a subcommittee is permitted to sign a report without having personally examined the subject under investigation, or having taken part in a discussion of its merits at a meeting of a subcommittee. The chairman of the subcommittee, through the Secretary of the Institute, must give formal and ample notice to the other members before making official examination or tests.

*Minority.*—Any member or members of a subcommittee can file a minority report at least three days prior to the meeting at which the report is to be considered and copies of such minority report shall be distributed to the general committee with the report of the majority.

*Reports.*—The final reports must be in the Secretary's hands at least one week previous to the general meeting.

*Correspondence.*—Correspondence between the subcommittee and applicant must be carried on through the office of the Secretary, in order that the official records shall be kept complete.

*Litigation.*—When the subcommittees find the subject under investigation is entangled in litigation, it shall defer action and report to the general committee. No further action can be taken unless the litigation is terminated or the general committee decide that the subcommittee is to proceed.

*Genuine Samples.*— Subcommittees must make certain that articles, processes, products, etc., examined are genuine samples of the subjects under investigation.

*Accuracy of Tests and Data.*—Subcommittees shall make sufficient investigations, tests, etc., of their own and shall not accept tests, data or information furnished by others, without first satisfying themselves as to the care exercised in making or gathering same and the accuracy thereof. They shall in no case recommend an award solely on tests, data or information furnished by parties in any way interested in the subject of the award.

*Awards by the Institute.*

The Institute, through its Committee on Science and the Arts, in accordance with the regulations as set forth herein, is entrusted with the award of the following Medals and Certificate of Merit:

The Elliott Cresson Medal,

The Howard N. Potts Medal,

The Edward Longstreth Medal of Merit,

The Certificate of Merit,

Recommendation to the Board of City Trusts, of the award of the John Scott Legacy Premium and Medal.

The significance of these awards, in order of their importance, is as follows:

*The Elliott Cresson Medal* (Gold Medal and Diploma).—This medal shall be awarded for discovery or original investigation, irrespective of commercial

value, adding to the sum of human knowledge; leading and practical utilizations of discovery; and invention, methods or products embodying substantial elements of leadership in their respective classes or unusual skill or perfection in workmanship.

*The Howard N. Potts Medal* (Gold Medal).—This medal shall be awarded for distinguished work in science or the mechanic arts; important development of previous basic discoveries; and inventions or products utilizing important principles or of superior excellence or for papers of superior excellence presented to the Institute and published in its JOURNAL.

*The Edward Longstreth Medal of Merit* (Silver Medal and Diploma).—Money Premium only when Accumulated Interest of the Fund permits. This medal shall be awarded for Meritorious work in science or the industrial arts; including papers relating to these subjects originally presented before the Institute or for meritorious papers presented to the Institute and published in its JOURNAL.

In the event of an accumulation of the fund for medals beyond the sum of one hundred dollars, it shall be competent for the Committee on Science and the Arts to offer from such surplus a money premium for some special work on any mechanical or scientific subject that the committee may consider of sufficient importance or for meritorious papers presented to the Institute and published in its JOURNAL.

*Certificate of Merit.*—Certificate of Merit shall be awarded to persons adjudged worthy thereof for their inventions, discoveries or productions.

In addition to the foregoing awards by the Institute, the Board of City Trusts of the City of Philadelphia awards the following premium and medal on the recommendation of the Institute, namely;

*The John Scott Legacy Premium and Medal* (Bronze Medal, Diploma and Premium of $20).—Awarded by the Board of City Trusts of the City of Philadelphia on recommendation of the Franklin Institute, acting through its Committee on Science and the Arts, by the terms of the deed of gift "to ingenious men and women who make useful inventions."

## ADVERTISEMENT OF AWARDS

The following special rules regarding the advertisement of the awards shall be observed:

1. Upon the adoption, by the Committee on Science and the Arts, of a report setting forth that a discovery, invention, improvement or manufacture is worthy of an award of the Elliott Cresson Medal, publication shall be made in three successive issues of the JOURNAL OF THE FRANKLIN INSTITUTE, stating that at the expiration of three months from the date of the first publication, the applicant will be entitled to receive the award of the said medal, unless within that time satisfactory evidence shall have been submitted to the Committee on Science and the Arts of the want of originality or merit in the supposed discovery, invention, improvement, or manufacture.

2. Upon the adoption, by the Committee on Science and the Arts, of a report setting forth that distinguished work in science or the arts is worthy of an award of the Howard N. Potts Medal, publication shall be made in three successive issues of the JOURNAL OF THE FRANKLIN INSTITUTE, stating that at the expiration of three months from the date of the first publication, the applicant will be entitled to receive the award of the said medal, unless within that time satisfactory evidence shall have been submitted to the Committee on Science and the Arts of the want of originality or merit in the supposed distinguished work in science or the arts.

3. Upon the adoption, by the Committee on Science and the Arts, of a report setting forth that meritorious work in science or the arts is worthy of an award of the Edward Longstreth Medal of Merit, publication shall be made in three successive issues of the JOURNAL OF THE FRANKLIN INSTITUTE, stating that at the expiration of three months from the date of first publication, the applicant will be entitled to receive the award of the said medal, unless within that time satisfactory evidence shall have been submitted to the Committee on Science and the Arts of the want of originality or merit in the supposed meritorious work in science or the arts.

4. The adoption by the Committee on Science and the Arts of a report setting forth that meritorious work is worthy of an award of the Certificate of Merit, shall be conclusive, without the advertisement that is required in the case of other awards by the Committee.

5. Upon the adoption by the Committee on Science and the Arts of a report setting forth that an invention or improvement is worthy of an award of the John Scott Legacy Premium and Medal, publication shall be made in three successive issues of the JOURNAL OF THE FRANKLIN INSTITUTE, stating that at the expiration of three months from the date of first publication, the Committee on Science and the Arts will recommend to the Committee on Minor Trusts of the Philadelphia Board of City Trusts, that it shall award the said premium and medal to the inventor, unless within that time satisfactory evidence shall have been submitted to the Committee on Science and the Arts of the want of originality in the supposed invention or improvement. In case no such objection to the final award of the premium and medal is made, the Secretary shall certify the recommendation of the award to the Committee on Minor Trusts of the Philadelphia Board of City Trusts.

HISTORY OF THE MEDALS.

*The Elliott Cresson Medal.*—Under date of February 18, 1848, Elliott Cresson, Esq., of Philadelphia, Pennsylvania, conveyed to Trustees, for the Franklin Institute, one thousand dollars of the six per cent. convertible loan of the President, Managers and Company of the Schuylkill Navigation Company—to hold the said sum and the interest to accrue thereon, for the following use and purposes:

1. The Trustees to keep the principal invested as it now is until it is reimbursed by the said Company, and immediately after such reimbursement to reinvest the said principal of one thousand dollars in such securities, bearing interest, as may by law be designated for the investment of trust funds. And from time to time, as the said principal sum may be reimbursed, to re-invest the same in like manner.

2. To cause suitable dies to be prepared for striking the gold medal out of the first sufficient moneys received for interest on the said sum of one thousand dollars. The dies to bear the following devices and inscriptions: The obverse,—a medallion likeness of the said Elliott Cresson with inscription around the margin "Elliott Cresson Medal, A.D., 1848." Reverse,—around the margin, "Awarded by the Franklin Institute of Pennsylvania." The centre to be filled by engraving the name of the party to whom awarded and the year in which the award may be made.

3. After the said dies have been prepared, and paid for out of the money received for interest, the said Trustees to cause to be struck, from time to time, such number of gold medals as the interest received will pay for, and to deliver the same to the Treasurer of the Franklin Institute, to be by him delivered to such persons or parties as the said Franklin Institute, by any rule or regulation they may adopt, may have awarded the same. The said awards, however, to be in all instances made either for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process or combination of materials in manufactures, or for ingenuity, skill or perfection in workmanship.

*The Howard N. Potts Medal.*—Howard N. Potts of Philadelphia, Pennsylvania, died July 24, 1906, leaving a will in which he provided for the establishment of this medal as follows:

I give and bequeath to "The Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts," and its successors, the sum of one thousand dollars, without deduction for taxes or charges; in trust to invest the same and apply the income thereof or such part or portion of it as may be adequate for the purpose, from time to time, to the purchase of a gold medal, to be awarded in the name of the said Franklin Institute for distinguished work in science or the mechanic arts.

*The Edward Longstreth Medal of Merit.*—In the month of May, 1800, Edward Longstreth, machinist and retired member of the Baldwin Locomotive Works of the City of Philadelphia, deposited with the Franklin Institute

in trust, a registered bond of the Baltimore Traction Company for the sum of one thousand dollars, for the founding and perpetuation of the Edward Longstreth Silver Medal; the interest accruing from said principal sum to be used in procuring and awarding said medals for the encouragement of invention, and in recognition of meritorious work in science and the industrial arts; the said awards to be made by the Franklin Institute through its Committee on Science and the Arts, under such rules as said Committee may adopt.

This donor further presented to the Franklin Institute twelve silver medals and the dies therefor designed and executed under the direction of a committee of the Institute with the approval of the donor.

The obverse of the medal bears the effigy of the donor, and is inscribed around the margin, "The Edward Longstreth Medal of Merit, founded 1890." On the reverse is inscribed around the margin, "Awarded by the Franklin Institute," the centre to be filled by the engraved name of the recipient, with the date and object of award.

On May 14, 1890, the Board of Managers of the Franklin Institute, by resolution, accepted on behalf of the Institute the gifts of the donor, and on September 17, 1890, the Institute, by resolution following, confirmed the acceptance:

"*Resolved*, That the Institute hereby confirms the action of the Board of Managers in accepting the gift of foundation of the Edward Longstreth Medal of Merit, and in expressing its grateful acknowledgments for the gift.

"*Resolved*, That the grant of the Edward Longstreth Medal, in accordance with the wishes of the donor, be entrusted to the Committee on Science and the Arts, subject to such conditions as the said Committee, with the approval of the Institute, may propose."

*The Certificate of Merit.*—At the stated meeting of the Institute, held on June 21, 1882, the following resolutions were adopted:

"*Resolved*, That the Committee on Science and the Arts of the Franklin Institute is hereby authorized to award, and issue to persons by said Committee adjudged worthy, a Certificate of Merit for their inventions, discoveries or productions, which certificate shall read as follows:

"The Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, awards to ——— ——— this Certificate of Merit. This award is made pursuant to the recommendation of the Committee on Science and the Arts.

Report No. —— Approved, ———19

———

*Chairman of the Committee on Science and the Arts.*

———*President.*

[SEAL] ———*Secretary.*"

*The John Scott Legacy Premium and Medal.*—John Scott, chemist, late of Edinburgh, by his will made in the year 1816, bequeathed the sum of four thousand dollars in the funded three per cent. stock of the United States, to the corporation of the City of Philadelphia, directing that the interest and dividend to become receivable thereon should be laid out in premiums, to be distributed among ingenious men and women who make useful inventions, but no such premium to exceed twenty dollars, and that therewith shall be given a copper medal with this inscription: "To the most deserving."

The Select and Common Councils of the City of Philadelphia, by an ordinance passed February 17, 1834, vested the award of the aforesaid premiums and medals in the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts.

The Legislature of the State of Pennsylvania, by an Act passed and approved June 30, 1869, created a Board of Directors of City Trusts, to whom was referred the charge of administration of all estates dedicated to charitable uses.

The control of the John Scott Legacy Premium and Medal was (by the Act of 1869) transferred to the Board of Directors of City Trusts.

This Board, by a resolution passed April 12, 1882, referred the matter, with instructions, to its Committee on Wills' Hospital and Minor Trusts.

The Committee on Wills' Hospital and Minor Trusts, by a resolution passed April 12, 1882, resolved that "they will favorably receive the names of any person whom the Franklin Institute may, from time to time, report to the Committee on Minor Trusts as worthy of receiving the John Scott Legacy Premium and Medal."

The Franklin Institute, by a resolution passed June 21, 1882, accepted the above, and referred the duty of making examinations, etc., to the Committee on Science and the Arts.

## FORM *A*.

THE FRANKLIN INSTITUTE
OF THE
STATE OF PENNSYLVANIA
FOR THE
PROMOTION OF THE MECHANIC ARTS.

(The following form must be filled-in, signed, and promptly returned to the Secretary of the Institute, at 15 South Seventh Street, Philadelphia, by the applicant for an examination and report upon an invention or discovery.)

In the matter of your application to the Franklin Institute for a consideration of your invention or discovery entitled _____ _____ the following data are requested for the information of the Committees on Science and the Arts:

1. What is the specific purpose of the invention?
2. What is the condition of the prior art in this regard?
3. What improvement is claimed to be effected by the invention?
4. How is the improvement effected?
5. What patents, if any, have been issued for this invention?
6. What citations, if any, were made in this regard by the Patent Office before allowance of patent claims?
7. Is the invention now in actual use?
8. If so, since when?
9. Where may it be seen in operation?
10. Are you prepared to submit drawings of the apparatus or device?
11. Are you prepared to submit a model of the apparatus or device?
12. If the invention is a composition of matter, are you prepared to submit specimens of the ingredients and of the compound sufficient for the purpose of experiments?
13. If the invention is a chemical process, are you prepared to give a demonstration of the same?

## FORM *B*.*

*This report is to be signed by all members of the sub-committee who participated in the investigation.

THE FRANKLIN INSTITUTE
OF THE
STATE OF PENNSYLVANIA
FOR THE
PROMOTION OF THE MECHANIC ARTS.

No. ——

REPORT OF SUB-COMMITTEE, dated _____

Investigating _____ _____

TO THE COMMITTEE ON SCIENCE AND THE ARTS:

Your sub-committee appointed to investigate the above subject reports as follows:

In consideration of the { discovery / excellence of construction / ingenuity and novelty / or } of _____

your sub-committee recommends the award of _____ to _____ of _____.

Respectfully submitted,

_____ *Chairman.*

_____

_____

_____

_____

FORM C.

THE FRANKLIN INSTITUTE
OF THE
STATE OF PENNSYLVANIA
FOR THE
PROMOTION OF THE MECHANIC ARTS.

HALL OF THE INSTITUTE,

Philadelphia, _____.

No. ——.

The Franklin Institute of the State of Pennsylvania, acting through its Committee on Science and the Arts, investigating _____ _____ reports as follows:

In consideration of the { discovery / excellence of construction / ingenuity and novelty / or } of _____

the Institute recommends that the Philadelphia Board of City Trusts shall award the John Scott Legacy Premium and Medal—or—the Institute awards the _____

to _____ of _____.

Adopted at the stated meeting of ——, 19—.

_____ *President.*

_____ *Secretary.*

Countersigned _____

*Chairman of the Committee on Science and the Arts.*

# FRANKLIN INSTITUTE

## MEMBERSHIP NOTES.

### Changes of Address.

DR. MORTON G. LLOYD, 215 South Oak Park Ave., Oak Park, Ill.
A. L. ADAMS, 721 Balboa Building, San Francisco, California.
WALTER E. DUNHAM, Supervisor, Motive Power & Machinery, care C. & N. W. Ry., Winona, Minn.
MARTIN L. GRIFFIN, The Oxford Paper Co., Rumford, Maine.
SAMUEL E. DOANE, Drawer "N," Cleveland, O.
CARL G. BARTH, 1937 North Thirty-third Street, Philadelphia.
C. E. SARGENT, Marine Building, 152 Lake Street, Chicago, Ill.

## OBITUARY.

**Emanuel, Jonathan Manly,** U. S. N., Retired, died at his residence, in Philadelphia, on Friday, June 24th, in his seventy-third year.

Mr. Emanuel was born in London, England, and came to this country in 1838. He was educated at Oakland Academy, Burlington, N. J., and in 1862 entered the naval service as third assistant engineer. He served with distinction throughout the Civil War and was promoted a number of times, retiring in 1891 with the rank of Passed Assistant Engineer.

During his service in the Navy, Mr. Emanuel invented an engine that is still used by the Government on several of its warships.

During the National Export Exposition, held at Philadelphia in 1899, he was one of the Judges. He became a member of the Franklin Institute in 1877, and has served on the Committee on Science and the Arts since 1887.

---

**Converse, John H.,** died at Rosemont, Penna., on May 3, 1910.

He was born December 2, 1840, at Burlington, Vt. In 1857 he entered the University of Vermont and after his graduation, in 1861, became a member of the Editorial Staff of the Burlington, Vt., Times.

Three years later he went to Chicago and connected himself with one of the leading railroad companies of the West. After two years in Chicago, he became Chief Clerk of the Altoona shop of the Pennsylvania Railroad.

In 1870 Mr. Converse came to Philadelphia and entered the service of the Baldwin Locomotive Works, becoming a member of the firm three years later, and ultimately the leading spirit of that great industrial establishment.

He was for many years a director, or otherwise actively interested in a number of Banking and Trust Companies, and since 1899 he was a member of the Philadelphia Board of City Trusts. He served as a member of the Philadelphia Board of Education, as President of the Fairmount Park Art Association and was Trustee of the Presbyterian Hospital and the Pennsylvania Academy of the Fine Arts.

## LIBRARY NOTES.

### Purchases.

ATTWOOD, E. L.—"War-ships." A text-book, Ed. 3.
BALDWIN, W. J.—"Heating." Ed. 16.
BALL, R. S.—"Natural Sources of Power."
BAXTER, W.—"Hydraulic Elevators."
BOTTONE, S. R.—"Magnetos for Automobilists."
CARPENTER, R. C.—"Heating and Ventilating of Buildings." Ed. 5.
DOOLITTLE, C. L.—"Treatise of Practical Astronomy."
FOLWELL, A. P.—"Water-Supply Engineering."
FOSTER, H. A.—"Electrical Engineer's Pocket Book," Ed. 5.
GERHARD, WM. P.—"Modern Baths and Bath Houses."
GERHARD, WM. P.—"Water Supply, Sewerage and Plumbing of Modern City Buildings."
HOBART and ELLIS.—"High-speed Dynamo Electric Machinery."
HOPWOOD, H. V.—"Living Pictures."
JACOBY, H. S.—"Structural Details or Elements of Design in Heavy Framing."
JOLY, J.—"Radio-Activity and Geology."
JONES, F. R.—"The Gas Engine."
KIMBALL and BARR.—"Elements of Machine Design."
LATTA, NISBET.—"American Gas Producer Practice."
LEVIN, A. M.—"Modern Gas Engine and the Gas Producer."
LEWIS, M. H.—"Waterproofing."
LYNDON, LAMAR.—"Development and Electrical Distribution of Water-Power."
MACLAURIN, R. C.—"Light."
MEHRTENS, A. C.—"Gas Theory and Design."
MOORE, W. L.—"Descriptive Meteorology."
MOLITOR, D. A.—"Hydraulics of Rivers, Weirs and Sluices."
POTAMIAN and WALSH.—"Makers of Electricity."
SCHUYLER, J. D.—"Reservoirs for Irrigation, Water-Power and Domestic Water Supply," Ed. 2.
SCRIPTURE, E. W.—"Researches in Experimental Phonetics."
SOPER, G. A.—"The Air and Ventilation of Subways."
SPITTA, E. J.—"Photomicrography."
WILSON, W. L.—"Elements of Railroad Track and Construction."
WOOD, DE VOLSON.—"Thermodynamics, Heat Motors, and Refrigerating Machines," Ed. 8.

**Gifts.**

Societe Ingenieurs Civils France. Annuaire. Paris, 1910.
Societe Internationale des Electriciens. Annuaire. Paris, 1910.
Maryland Geological Survey, vols. 7 and 8, 1908–09. Baltimore, 1909.
Maryland Weather Service, vol. 3. Baltimore, 1910.
Royal Society of Canada, Proceedings and Transactions 1909.
Nova Scotian Institute of Science Proceedings and Transactions, vols. 11 and 12, Halifax, 1908.
McGill University and College Calendar, 1910–11, Montreal, 1910.
"Mechanics of the Earth's Atmosphere," By Cleveland Abbe. Smithsonian Institute, Washington, 1910.
Engineer's Directory for 1909. London, 1910.
Interstate Commerce Commission Report, 1909. Washington, 1910.
Massachusetts Railroad Commissioners Annual Report, 1909. Boston, 1910.
Michigan Department of Labor Report for 1909. Lansing, 1910.
Victorian Institute of Engineers Proceedings, vol. 10. Melbourne, 1910.
West Virginia Mines Department Report. Charleston, 1909.
Canadian Mining Institute Journal, 1909. Montreal, 1910.
Drexel Institute Year-Book, 1909–1910. Philadelphia, 1910.
K. K. Geographische Gesellschaft in Wien. Mitteilungen, vol. 52, 1909, Wien, 1909.
Leland Stanford Junior University Register, 1909–1910.
Ontario Agricultural and Experimental Union Report, 1909. Toronto, 1910.
Ontario Fruit Growers' Association Report, 1909. Toronto, 1910.
Ohio Mechanics Institute Annual Catalogue, 1910. Cincinnati.
Connecticut Special Laws, vol. 15, 1909. Hartford, 1910.
Connecticut Labor Bulletin. Hartford, 1909.
Canadian Society of Civil Engineers, vol. 23, 2, 1909. Montreal, 1910.
Water Supply Commission of Penna. Report for 1908. Harrisburg, 1910.
American Institute Mining Engineers, vol. 40, New York, 1910.
Vermont Insurance Report. Bellows Falls, 1909.
Wisconsin Agricultural Experiment Station 25–26. Annual Reports, 1908–09, Madison.
United States Brewers Association Year-Book, 1910. New York, 1910.
United States Civil Service Commission, 26th Report. Washington, 1910.
Statistical Abstract of United States, 1909. Washington, 1910.
Commerce and Navigation of the United States, 1909. Washington, 1910.
Illinois Geological Survey Bulletin, Nos. 12, 13, 14. Urbana, 1909.
Massachusetts Board Gas and Electric Light Commissioners Report, 1909, Boston.
Contributions from the Jefferson Physical Laboratory of Harvard University 1909.
Waltham City Documents, 1909. Waltham, 1910.

# SECTIONS

*Section on Mining and Metallurgy.*—The stated meeting of the Section was held in the Hall of the Institute on Thursday, May 19, 1910, at 8 P.M., with Prof. A. E. Outerbridge, Jr., in the Chair. The meeting was attended by twenty-one members and visitors. The minutes of the previous meeting were read and approved.

Dr. Edgar T. Wherry of Lehigh University read a paper entitled "The Copper Deposits of Franklin-Adams Counties." The geology and the igneous rocks of the region were described. An account was given of the copper minerals and their mode of occurrence. Native copper predominates, although carbonates, silicate and sulphide of copper also occur. The source of the copper and the mode of formation of these deposits were discussed. The lecture was illustrated with lantern slides and with a specimen of the ore.

The paper was discussed by Professor Outerbridge, Dr. Goldsmith, Dr. Wherry and others, and was referred to the Committee on Publications.

A vote of thanks was tendered the speaker. The Meeting then adjourned.

JOSEPH S. HEPBURN,
*Acting Secretary.*

**Artificial Silk.** FRANCIS J. G. BELTZER. (*Moniteur Scientifique*, xxiv, 821.)—The manufactories of artificial silk with a nitro-cellulose base, are constantly increasing their production, and the number of factories also steadily increases. Besides the long-established factories in France, Belgium, Germany and Italy, others have been founded in Russia, Hungary, Austria, the United States and elsewhere.

The production of cupro-ammoniacal silk is also greatly enlarging. The factories of Glanzstoff silk produce about six million pounds of textiles with a cupro-ammoniacal-cellulose base. Viscose silk is developing strikingly, producing about 2 million pounds.

In England a plant for the production of patent lustre-silk has been installed at a cost of $250,000. In Germany, Bohemia and the United States many factories have started. The old methods of production are continually developing and perfecting the tenacity and elasticity of the thread, both in the dry and moist condition. Cellulose, as pure as possible, is the base for all these many manufactures.

## PUBLICATIONS RECEIVED.

North Carolina Geological and Economic Survey. Bulletin No. 21. The Gold Hill Mining District of North Carolina. By Francis Baker Laney. 137 pages, plates, maps, 8vo. Raleigh, State Printer, 1910.

North Carolina Geological and Economic Survey Economic Paper No. 15. The Mining Industry of North Carolina during 1907 with special report on the mineral waters. By Joseph Hyde Pratt, Ph.D. 176 pages, plates, maps, 8vo. Raleigh, State Printers, 1908.

Directory of Metallurgical and Chemical Material, 1910. Second Edition. 219 pages, 12mo. New York, Metallurgical and Chemical Engineering. Price, paper, 50 cents.

Standard Specifications for Creosoted Wood-block Pavement. Requirements and Tests for Quality of Paving Brick. By J. W. Howard, consulting engineer. 4 leaflets, quarto. New York City, author, 1910.

Carb-ox Company. Catalogue of gas analysis instruments and allied specialties. 16 pages, illustrations, narrow 8vo.

U. S. Coast and Geodetic Survey. Results of observations made at the coast and geodetic survey magnetic observatory near Honolulu, Hawaii, 1905 and 1906, by Daniel L. Hazard, Computer, Division of terrestrial magnetism. 112 pages, illustrations, quarto. Washington, Government Printing Office, 1910.

U. S. War Department. Annual reports, 1909. 9 volumes, plates, maps, tables, 8vo. Washington, Government Printing Office, 1909. Contents: Reports of the Secretary of War, Chief of Staff, Adjutant-General, Inspector-General, Judge-Advocate General, Quartermaster-General, Commissary-General, Surgeon-General, Paymaster-General, Chief Signal Officer, Chief of Coast Artillery; Departments of the East, of the Gulf, of the Lakes, of the Missouri, of Dakota, of Texas, of the Colorado, of California, of the Columbia; Philippine Division, Department of Luzon, Department of the Visayas, Department of Mindanao, Army of Cuban Pacification, Military Academy, Military Parks, Chief of Engineers, Chief of Ordnance, The Philippine Commission, Governor of Porto Rico; Acts of First Philippine Legislature.

Popular v. Delegated Government. Oregon has the best system of popular government in the world to-day—The Australian ballot—Registration of voters—Initiative and Referendum—Direct Primary—Corrupt practices act—Recall—An absolute government by the people. Speech of Hon.

Jonathan Bourne, Jr., of Oregon in the Senate of the United States, Thursday, May 5, 1910. 16 pages, 8vo. Washington, Government Printing Office, 1910.

Canada Mines Department, Mines Branch. Annual report of the division of mineral resources and statistics on the mineral production of Canada during the calendar 1907 and 1908. John McLeish, B.A., Chief of the Division. 286 pages, 8vo. Ottawa, Government Printing Bureau, 1910. Price in paper 15 cents.

Argentina, Centenario de la Republica. Exposicion internacional de ferrocarriles y transportes terrestres, Buenos Aires Mayo a Novembre, 1910. Circular No. 19. Idioma Ingles. 12 pages, illustrations, quarto. Buenos Aires, 1910.

Der Verein Deutscher Ingenieure und seine Arbeiten. Herausgegeben aus Anlass der Weltausstellung in Brüssel, 1910. 47 pages, illustrations, narrow 16mo. Berlin, Society, 1910.

Turner-Fricke Manufacturing Company. Catalogue of Gas and Gasoline Engines. 26 pages, illustrations, narrow 12mo. Pittsburg, Penna. (n. d.)

U. S. Navy Department. Report of Board on Comparative Trials of the Scout Cruisers Birmingham, Salem, Chester. 90 pages, 8vo. Washington, Government Printing Office, 1910.

Alpha Portland Cement Company. Alpha Portland Cement for Eternity. 48 pages, illustrations, 4to. Easton, Penna., Alpha Portland Cement Co., 1910.

Contractors Supply and Equipment Co. Catalogue. 44 pages, illustrations, oblong quarto. Denver, Col., Company, 1910.

---

**Chrome-Steel Permanent Magnets.** W. BROWN. (*Sci. Proc. Roy. Dublin Soc.*, xii, 349.)—Assuming, as stated by Mme. Curie, that small quantities of silicon have little or no effect on the magnetic properties of steel, the magnetic moment per gram is found to increase uniformly with the increase of chromium, until a maximum is reached with 2.5 per cent. of chromium, from which it falls as the chromium reaches 3.5 per cent. Any further addition of chromium does not affect the magnetic moment. The maximum points are liable to disturbance through varying quantities of carbon, silicon, manganese, tungsten and copper, which also affect the retentiveness of the magnets.

# CURRENT TOPICS

**Gredag.** (*Iron Age*, lxxxv, 22.)—Gredag is the trade name adopted by the Internat. Acheson Graphite Co. for its graphite grease, in order that it may be distinguished from grease products which contain impure natural graphite. The graphite, blended with a high-grade grease, in Gredag is an electric furnace product, as pure as can be made. All the merits of both graphite and grease are combined in Gredag, making a lubricant of high quality and value. This concern now produces three lubricants containing deflocculated Acheson graphite, Aquadag, Oildag and Gredag.

**The Electric Drive in Industrial Establishments.** (*Eng. Record*, lxi, 21.)—The value of the electric drive was clearly shown after the explosion of four out of the eight 400 h.p. boilers in the plant of the Pabst Brewing Co., at Milwaukee, which is operated electrically throughout. To shut down the plant would involve a heavy loss, for unless the processes are carried on with regularity, the product at various stages becomes spoiled. In this case it was possible to make arrangements with the Milwaukee Electric Railway and Power Company for 600 k.w. Three transformers were put in place in a few hours, and in a short time the operation of the brewery was resumed, saving a considerable direct loss and much inconvenience in other respects.

**Behavior of Fluorides in the Preservation of Wood.** R. Nowotny. (*Oester. Chem. Zeit.*, 1910, xiii.)—Experiments made by various methods on the impregnation of wood (telegraph poles, etc.), with solutions of fluorides, with special reference to selective absorption, show that when wood is steeped in a solution of zinc hydrogen fluoride $ZnF_2$, 2HF, containing free hydrofluoric acid the solution is absorbed as a whole, no change in composition being observed. The surface of the treated wood becomes brown, but its quality does not suffer in any way. If, however, the solution be forced through the green wood by hydrostatic pressure, as in Boucherie's method, the ratio of zinc to fluorine in the liquor becomes greater, showing that fluorine is extracted from solution by the wood; and that free hydrofluoric acid is extracted to a greater extent than the combined acid.

**Magnetic Properties of Electrolytic Iron and Some Steels.** C. F. Burgess and J. Aston. (*Met. and Chem.*, 1910, viii.)—Data are given on a series of tests on the magnetic quality of various electrolytic irons, both as deposited and after subsequent melting

and forging. A considerable variation of quality existed in the forged bars before annealing, not accountable for by differences of purity, but when they were heated to 675° C. and slowly cooled, a practically uniform high quality resulted. Annealing at 1000° C. improved the quality for the lower ranges of magnetizing force to a certain extent, but was less satisfactory than annealing at 675° C. Quenching from 900° C. caused slight deterioration for all magnetizing forces. Data are also given of similar tests on various commercial steels, showing that refining improves the magnetic qualities, but that the amounts of impurities generally met with in commercial practice do not result in serious deterioration of the quality. The heat and mechanical treatment is, however, of extreme importance and a comparatively low-grade steel may be greatly improved by judicious annealing.

**International Geological Congress.** (*Iron Age*, lxxxv, 22.)—The eleventh session of this Congress will be held at Stockholm, Sweden, on August 18 to 25, 1910. The general secretary is Professor J. G. Andersson, Stockholm. A number of trips have been arranged to Swedish iron mines and iron and steel works. The executive committee, with the assistance of geological surveys and eminent geologists from various countries, is compiling a summary of the iron ore deposits of the world, designed to show the amount and distribution of the world's supply of iron ore. The reports from the different countries, in the original languages, are collected in two quarto volumes, containing 1100 pages. Professor J. F. Kemp, Columbia University, New York, furnished the report for the United States.

**Contraction of Metals and Alloys.** F. WUST. (*Metallurgie*, vii, 321.)—For the measurement of contraction the author has designed an apparatus, which eliminates the uncertainty of the levers used to magnify the contraction in earlier designs. The metals are cast into bars of 500 mm. length in a mould, into the ends of which project stout iron wires ending in coils which become embedded in the cast bar. The other ends of the wires are connected to pistons operating in water-tight cylinders. The two cylinders are filled with distilled water and connected to a capillary measuring gauge. Changes in the volume of the bar are indicated by the movement of the liquid in the tube, which is read by one observer, while another observer takes a cooling curve by means of a thermocouple placed in the centre of the bar. The results are plotted in the form of temperature-contraction curves, which are compared with the "inverse rate" cooling curves. Experiments were conducted with the metals lead, tin, zinc, aluminum, copper, bismuth and antimony, and a number of their technically important alloys. The results lead to the conclusions that: (1) alloys whose components are mutually insoluble in the solid contract less than either

of the constituents, the eutectic alloy having the lowest coefficient of contraction; (2) alloys consisting of one or more solid solutions contract more than the constituent metals; and (3) there is no law connecting contraction and melting point, either for metals or alloys.

**Carbon Bisulphide as a Gaseous Product.** J. DEWAR and H. O. JONES. (*Proc. Roy. Soc.*, A83, 1910.)—The authors find that carbon bisulphide changes to a gaseous product condensable and explosive near the temperature of liquid air. When a rapid current of carbon bisulphide vapor, at a pressure of about 1 mgm., is submitted to the action of the silent electric discharge, it is partially decomposed into sulphur and a new volatile sulphide of carbon, probably carbon monosulphide; this is condensed, along with the unchanged carbon bisulphide, at the temperature of liquid air, and polymerizes at a slightly higher temperature with explosive violence, to give a brown solid, which is apparently identical with the known polymeric form of carbon monosulphide. The new gas is not completely destroyed by passing the gaseous mixture from the ozonizer rapidly through a short length of red-hot tube; it quickly polymerizes at the ordinary temperature, even at low pressures, and in the presence of a large excess of carbon bisulphide.

**Gases Containing Helium from the German Potash Deposits.** E. ERDMANN. (*Ber.*, 1910, xliii.)—In one of the Leopoldshall workings a blower of inflammable gas has been issuing at a depth of 450 meters since August, 1904. The gas contains 83.6 per cent. of hydrogen, 4.4 of methane, and 12 of other gases, including helium and neon. The helium greatly preponderates over the neon, but the two together form about 0.17 per cent. of the original gas, or nearly 1 per cent. of the gas after the removal of the hydrogen. The author attributes the existence of the helium to the degradation of radium salts originally contained in the waters of the sea which furnished the deposits, and he regards the hydrogen as resulting from the radio-active decomposition of water, the equivalent oxygen having disappeared in converting ferrous into ferric salts in the carnallite.

**Preparation of Zirconium.** L. WEISS and E. NEUMANN. (*Zeit. anorg. Chem.*, lxv, 248.)—Electrodes of zirconium were made by compressing Zr. powder into sticks and heating it in hydrogen, and used in an arc furnace filled with neutral gas. The metal obtained had a brassy color, which turned blue on heating, was very brittle and could be crushed in a mortar. Its hardness is 7 to 8, and its density 6.4 at 18° C. Its specific heat is 0.0804 and the heat of combustion 1959 cal. per gramme. Powdered Zr. is easily ignited, the compact metal is harder to ignite. $Zr.H_2$ was made by heating the metal in hydrogen. When burned in oxygen $Zr_2O_3$ was formed.

**A Method of Renewing Carbon Filaments.** SCHMITTUTZ. (*Electro. tech. Zeit.*, xxxi, 355.)—The lamp is supposed to have burned long enough to blacken the bulb, but not to have broken the filament. The top of the lamp bulb is opened, and a tube fused to it at this point. The bulb is then sufficiently heated to burn off the carbon deposit. A small amount of some suitable hydrocarbon is then introduced into the bulb and a vacuum produced. Current is passed through the filament and carbon is thus deposited in a manner similar to that adopted in the ordinary flashing process. The cost is said to be about 5c. per lamp.

**Glass and Porcelain.** O. PARKERT. (*Sprechsaal*, 1910, xliii.)—New methods of decorating glass and ceramic ware have been opened up by the use of reduction colors. If a silver mirror be formed by dipping a piece of ware in a solution of a silver salt and reducing with sugar and tartaric acid, many varieties of red and blue can be obtained by treating it with potassium permanganate solution for varying periods. If the permanganate be applied only in places, iridescent effects are obtained. Similar colors are given by gold, which is best applied in the form of chloride, dissolved in a solution containing 10–15 Gm. of sodium chloride per litre. The ware should be dried in a dark room. It is overglazed and fired in a muffle. The color effects are quite permanent.

**Intrinsic Brightness of the Sun.** C. NORDMANN. (*Comptes rendus*, cl, 448.)—The effective temperature determined with the author's pyrometer was found to be about 5320° C. absolute. Now the brightness of an incandescent body emitting white light varies sensibly as a function of the temperature, and this law has been verified by comparison with numerous terrestrial light sources. Taking into consideration the absorption of the solar atmosphere, the effective temperature of the photosphere is probably about 6450° C. absolute. The corresponding brightness of the mean effective layer is then about 319,000 decimal candles per square cm. The solar surface is thus considered to behave very much like a black body, and to have an emissive power of nearly unity.

**Metallic Tungsten.** L. WEISS, A. MARTIN and A. STIMMELMAYE. (*Zeit. anorg. Chem.*, lxv, 279.)—Experiments made on the reduction of wolframite, barium and calcium tungstates, tungsten oxide and tungsten sulphide by means of aluminum, zinc, magnesium and carbon, showed that none of them would give the pure reguline product desired. Experiments are described in which tungsten powder was melted in a vacuum furnace by the magnetic arc. The electrodes were of tungsten powder, strongly compressed into sticks and heated in hydrogen to make it a conductor. The arc was deflected into a zirconia crucible, into which the molten metal dropped as the ends of the electrodes fused off. The proper-

ties of the metal varied with the rate of cooling; when cooled rapidly it was brittle and had a granular fracture, a hardness of 7.5 and its density was 18.71 to 18.74; when cooled slowly it was malleable, had a conchoidal fracture, a hardness of 6.5, and its density was 18.72 to 18.74. The specific heat was 0.0358 and the heat of combustion 1047 cal. per gramme.

**The Mother Lode Mine in British Columbia.** R. H. ALLEN. (*Eng. Min. J.*, lxxxviii, 1101.)—The mine is situated at Deadwood Camp and is connected with the smelter by a spur of the Canadian Pacific Railway. The ore is from 30 to 200 feet in width, and belongs to the so-called "magnetic" type; it includes the minerals magnetite, chalco-pyrite and pyrite, with a little blende, galena, pyrrholite and occasionally a little arsenopyrite; intermixed with calcite, actinolite, garnet, epidote and quartz. The most valuable metal is the copper, but the ores will average more than $7.00 per ton in gold and silver. Tests show that the ores with 2 per cent. copper carry the most gold, while those with as high as 30 per cent. copper carry no gold. There is no limestone within the ore body. The output varies from 1000 to 1600 tons daily. The labor cost per ton of ore does not exceed 65 cents.

**Gas from Heated Metal.** G. BELLOC. (*Comptes rendus*, cxlix, 672.)—When steel is heated in a vacuum, gas is evolved at 150° C., and at 400° C. the volume evolved becomes considerable. Gas can not be completely driven out from steel by long continued, strong heating; rather the metal must be considered as a practically inexhaustible gas reservoir.

**A New Sclerometer.** A. L. PARSONS. (*Am. Jr. Sci.*, xxix, 162.)—This new instrument differs from older ones in that the force necessary to make the scratch is measured by a spring and not by weights. It must, of course, be calibrated, that is, the force necessary for bending the spring must be determined in weights. So far the instrument has been applied only to polished metal and glass surfaces and not to minerals. The advantages claimed are rapidity of observations, compactness and cheapness.

**The New Nitrogen Fertilizers.** H. VON FEILITZEN. (*J. Soc. Chem. Ind.*, xxviii, 723.)—Since 1904 extensive experiments have been made with fertilizers obtained from the atmosphere by the help of the electric furnace. These experiments were made partly in pots and in wooden boxes, sunk in the soil, and also field experiments at Flahult. The plants grown were oats, potatoes and hemp. The effect of calcium nitrate was at least equal to that of sodium nitrate in all the experiments. In the case of oats the yield of grain in relation to straw was increased more by calcium nitrate than by sodium nitrate. The hygroscopicity of the calcium nitrate

is its only drawback. Experiments were also made with calcium cyanamide. Its decomposition in the soil produces compounds possibly injurious to vegetation. Comparative experiments showed this fertilizer should always be applied some time before sowing the seed, to avoid injury during germination; and as a top dressing it must always be applied very early, that the plants may not suffer. In wet seasons calcium cyanamide seems to give better results than in dry seasons.

**Luminous Efficiency of the Firefly.** H. E. IVES and W. W. COBLENTZ. (*Bull. Bur. Standard*, vi, 321.)—By photographing the spectrum of the local firefly, *Photinus pyralis*, the radiation from it was shown to be limited to the yellow-green region, $\lambda$ 510-670. There is a maximum of intensity at 570, but the band is not composed of fine lines. The computed luminous efficiency (light radiation) is 96.5 per cent., as against 0.4 per cent. for the carbon glow lamp.

**Concrete Floors in Vessels.** (*Eng. Record*, lxi, 25.)—Concrete floors were tried in a number of wooden vessels carrying ore and coal on the Great Lakes as a substitute for wooden floors, which suffer severely from the clam-shell buckets. The concrete floors are said to stand the wear very well.

**Gaseous Suspensions.** M. DE BROGLIE. (*Physik. Zeit.*, xi, 33.)—Some kinds of smoke observable in gases consist of fine particles, observable in the ultra-microscope, of radius between several $\mu\ \mu$ and several hundred $\mu\ \mu$. These show Brownian movements capable of being photographed and agreeing with a formula of Einstein's. In this respect they are surprisingly like particles in liquids. They differ electrically at times in being either negative or positive or neutral, while those in liquids are never neutral.

**Copper Clad Steel.** W. TATTIN. (*J. Ind. Eng. Chem.*, i, 670.)—Numerous attempts have been made to cover steel with a coat of copper of any desired thickness and to weld the two metals so firmly that the combination could be submitted to any of the usual methods of working metals without destroying the integrity of the weld. This desired result was only attained by the process to be described. Steel of any description, composition or shape is rolled into rounds and cut into 26-inch billets, to make wire rods, and is sand blasted and pickled to remove scale. The billet, drilled and tapped at each end, is hung by a rod and bushing screwed into one end in a pre-heater and brought to a red heat. The billet is then drawn into a tube by means of a rod screwed into the top of the bushing. This rod slides in the centre hole of a three-jawed chuck, which holds the tube and centres the billet in it. A steel flange is then screwed on the bottom of the billet, thus forming with

the tube a mold in which the billet is the core. The mold and billet are now carried to a pot of specially prepared copper, in a super-molten condition. The billet, and its attached flange, are inserted in the copper and kept there long enough to wet the surface of the steel and to form an alloy film. The billet is then drawn from the copper into the tube, and the billet and its mold are carried to a second pot containing commercially pure copper, in which the final coat of copper is applied. The mold is filled with copper and after withdrawal when the copper has solidified, the chuck, rod, and flange are unscrewed. The tube and its contents are then placed in a ram and the copper-clad steel billet is pushed out of the mold. The billet is now given a washing heat and is rolled to the desired size. The proportional areas, of the copper and steel remain practically constant during the reduction in size. The tensile strength of the copper-clad steel is equal to, and sometimes greater, than that of a steel of a similar composition, but with a sectional area equal to that of the clad metal. There are many uses for copper clad steel; the most obvious is as a wire for electrical and mechanical purposes. The breaking weight and elastic limit of a No. 10 copper wire are respectively 530 and 293 lbs., while those of a No. 14 copper clad is 760 and 320 lbs. The one weighs 116 lbs. per mile and the other 61 lbs. Comparing copper clad with galvanized iron telephone wire, a much smaller size of copper-clad may be used for the same ohmic resistance. The resistance of copper-clad steel is equal to that of copper, and is immeasurably greater than that of steel.

**Resinite.** (*British Jrnal of Photo*, June, 1910.)—The American Consul at Chemnitz mentions a new substance, invented in Germany, for replacing celluloid, ivory, etc., known as resinite, for which a number of applications has been found. It is produced in a variety of modifications by the union of formaldehyde and phenol, with certain metallic salts. In one form it appears like ordinary resin, but in another form can be poured as liquid into moulds. When cold it is transparent, with a ruby tint, infusible and unaffected by chemical reagents. It is well adapted for making ornaments, imitation jewelry, and most purposes where enamel or enamel varnish is employed. It has the great advantage, compared with celluloid, of being non-combustible. [This is evidently "Backelite."—Obs. See JOUR. FRANKL. INST., clxix, 55.

**Metallic Carbonyls.** L. MOND, H. HIRTZ, and M. D. COWAP. (*Trans. Chem. Socy.*, 1910, xcvii, 198.)—Experiments on the action of carbon-monoxide, under high pressure and at temperatures up to 450° C., upon finely divided (pyrophoric) metals, have led to the preparation of a new cobalt carbonyl, $Co(CO)_3$, and molybdenum and ruthenium carbonyls. They all have very similar chemical properties; they decompose, when heated, into carbon mon-

oxide and the respective metals, which are deposited as mirrors, and they are not attacked by non-oxidising acids, though quickly dissolved by oxidising acids, and especially by aqueous solutions of the halogens, with the evolution of carbon monoxide. They are more or less soluble in the usual organic solvents, but are insoluble in water. Attempts to prepare manganese, chromium, tungsten, palladium and rhodium carbonyls have been unsuccessful.

**The Passage of Vapors Through Glass.** C. ZENGHELIS. (*Z. Phys. Chem.*, xxxii, 425.)—After his earlier observations had been criticised, the author repeated them and still finds that silver foil inclosed in a vessel of thin glass, from which the air has been partially exhausted, is attacked when the vessel is surrounded by another containing iodine crystals and closed with paraffin wax. He shows that the effect cannot be attributed to impurities in the atmosphere of the surrounding vessel, or to impurities in the paraffin. He gives data of experiments, one of which showed a decided loss in weight (15.7 m. grms) of a vessel containing 0.8 c.c. of bromine after standing 117 days. The facts that the action on the silver is local, and that the phenomenon varies with different vessels, lead the author to assume the existence of invisible pores through which gases may pass, as a frequent occurrence in thin glass vessels.

**Alloys of Titanium and Silicon.** (*Soc. Chem. Ind.*, xxix, 10.)—The Titanium Alloy Manufacturing Company have patented a process for producing such alloys, containing from 20 to 75 per cent. of silicon and from 5 to 70 per cent. of titanium. Silver sand is mixed with rutile or titanium oxide in the proportion desired and powdered carbon added so that two atomic weights of carbon are present for each molecular weight of silica or titanium oxide. The whole mixture is then reduced in an electric furnace of the arc type. One electrode is the graphitic interior of the furnace itself, the other is vertically movable in a central cavity. At the close of the reaction the fused alloy is withdrawn through a tap-hole. By adding a definite proportion of scrap iron to the charge, ferro-silico-titaniums are obtained. Similarly cupro-silico-titaniums can be produced.

**Commercial Rust Proofing.** (*Iron Age*, lxxxv, 21.)—The Bradley process of rust proofing is a hydrogen gas treatment. The article to be rust proofed is placed in a muffle, where it comes in contact with hydrogen gas and other materials necessary to the process and is then subjected to heat. This changes the surface, forming an alloy which resists the action of oxygen in air or water. The process can be used on bolts, nuts, or other threaded articles, as it causes no interference with the threads, as plating does. In addition to the rust proofing, the treated articles are benefited by

the careful cooling, which anneals them. The process cannot be used on hardened or tempered pieces. The color obtained is a dark, rich, blue-black, well adapted for builders' hardware, or any highly finished articles.

**The First Girod Furnace in this Country.** (*Iron Age*, lxxxv, 21.)—The Simonds Manufacturing Company, Fitchburg, Mass., is installing a Girod electric furnace in the crucible steel department of its Chicago plant. At Lockport, electric furnaces of larger size than the experimental one will be installed if the results at Chicago meet expectations. The Girod furnace is in use in numerous European works, their capacities ranging from two to twelve and one-half tons.

**Thermal Conductivity of Fire-Clay.** J. K. CLEMENT and W. L. EGG. (*Eng. Rec.*, lxi, 24, 754.)—These gentlemen investigated the thermal conductivity of fire-clay, to obtain information concerning the loss of heat through the walls of boiler furnaces. A resistance coil was inserted in a fire-clay cylinder about 16 inches long and 4.8 inches in diameter and provided with a hole about 1.4 inch in diameter for the coil. Four small longitudinal holes were made for the insertion of thermo-couples for measuring the temperature. The test cylinder was then inserted in a larger fire-clay cylinder in order to maintain higher temperatures in the former and a more uniform radiation from it. The ends were covered to prevent loss of heat there. The electrical apparatus was arranged so that a current could be kept constant within a variation of 0.1 ampère for several hours. Twelve cylinders were tested, embracing three varieties of fire-clay. The conductivity ranged from 0.00221 to 0.00362, averaging 0.00267.

**Influence of Boiler Incrustations.** G. REUTLINGER. (*Zeit. des Verein deutscher Ing.*)—The effect of incrustations in retarding the transmission of heat has been greatly overestimated; yet they may cause dangerous overheating of the plates. An incrustation ¼ inch thick may cause as much as 20 to 30 per cent. loss of heat according to the temperature of the firing gases. Oil or fat causes greater losses. A coating of tar, ⅛ inch thick, caused a loss of 30 to 45 per cent. If the transference of heat is effected by contact and not by radiation, the losses caused by incrustation, when the heating is done by hot gases, may not be more than one-third the above amounts, but they may reach 70 to 80 per cent. when hot water or saturated steam is the source of heat. In such cases, *e.g.*, steam heated evaporators, brewing coppers, etc., incrustations should be carefully avoided. When the temperatures of the heating medium and of the material heated do not remain constant, the following conclusions are reached. 1. *Heating medium constant, heated fluid variable.* For apparatus of moderately large size and not too

heavily forced, the loss may reach 15 to 30 per cent.; for smaller heating surface, or rapid circulation it may be 50 per cent. *Heating medium variable, heated fluid constant, e.g.*, boilers. The loss may amount to about 7 per cent. if contact heating alone be considered, or 5 per cent. with contact heating and radiation. *Both heating medium and heated fluid variable.* Saturated steam losses of 25 to 30 per cent.; heated by gases or super-heated steam, losses of only 5 to 15 per cent.

**Development of Silver Bromide-Gelatin Plates in Hot Countries.** L. J. BUNEL. (*Bull. Soc. Franc. Phot.*, i, 174.)—In developing gelatin-bromide plates in hot climates it is preferable to use either diaminophenol in acid solution, or metol-quinol in presence of acetone, and in absence of alkali, hydroxide or carbonate. The addition of potassium or sodium sulphate to the developer has been found to be the best means of making the gelatin insoluble and preventing "frilling." To avoid the production of bacteria during the final operations, they should be conducted as quickly as possible; antiseptics, such as formaldehyde, etc., are ineffective. Suitable formulæ are given for making up diaminophenol and metol-quinol developers and a combined fixing and hardening bath, containing potassium meta-sulphite and chrome-alum thiosulphate, and in addition 0.5 per cent. of potassium cyanide which prevents the precipitation of sulphur.

**Increasing the Sensitiveness to Light of Asphaltum.** G. VALENTA. (*Phot. Corresp.*, xlvii, 238.)—Asphaltum is heated, on a water bath, with 6 to 8 per cent. of its weight of sulphur chloride, diluted with four or five volumes of carbon bisulphide. When the evolution of hydrochloric acid has ceased, a portion of the solvent is distilled off and the residue diluted with benzene; the solution is now coated on metal plates. The plates thus formed are practically as sensitive as those coated with bichromated albumin.

**Absorption of Barium by Plants.** H. COLIN and J. DE RUFZ. (*Comptes rendus*, cl, 1074.)—Pease germinated in distilled water and then transferred to a very dilute solution of barium nitrate continued to grow and barium was absorbed. A dry root weighing 0.93 Gm. gave 0.146 Gm. of ash which yielded 0.015 Gm. of barium sulphate.

**A Safe for Radium.** (The *Times*, May 31, 1910.)—A safe has been made by Messrs. Chubb & Sons for the British Radium Corporation. It is constructed from the designs of the technical advisers to the Corporation, especially for the storage and protection of radium. Though only about 3 feet high it weighs one and one-half tons. It is constructed with an interior shell of 3-inch lead and an outer case of 3-inch steel. It is provided with a circular

lathe-turned door, which has a "dead" fit, and an ingenious contrivance for immediately remedying any wear and tear from opening and shutting. To prevent loss of emanations when the door is opened, two valves are fixed in the door, through which tubes of mercury are passed to collect and store the emanations.

**Three-Color Photographic Process.** R. BERTHON, France.—A patent has been secured by M. Berthon for this process. Photographic plates or films are prepared, having on one side a panchromatic emulsion, and on the other side a series of very small, transparent, spheroidal grains or cylindrical bands, close together, which are formed by embossing a gelatin or celluloid film. Plates made in this way are exposed with the emulsion farthest from the lens, behind an objective in which is fixed a screen composed of the three fundamental colors. The resulting negative is reversed, and may then be projected through the objective and screen, giving a colored projection. The grained or embossed screen acts as a series of lenses in front of the emulsion, causing the separation by refraction of the images of the screen projected in microscopic condition at points close together on the sensitive film; the result is similar to that obtained by a grained or lined screen, except that in this process more light passes to the emulsion.

**Camphor Monopoly in Japan.** (*Zeit. Angew. Chemie*, xxiii, 736.)—The Japanese camphor monopoly tried to control the market by increasing the price from 65 cents in 1903 to $1 in 1906. The production of camphor was stimulated by giving the planter a higher price and by planting new trees to the number of 28 millions. After the introduction of German artificial camphor, and the revival of the Chinese production, the Japanese monopolists recognized that they could not dictate terms. The price was greatly reduced, and since 1908 Japanese camphor was sold in London and New York at $34 to $35 per 112 pounds. To reduce the loss part of the camphor oil was sold to the refineries and the separated camphor taken back, whereas previously the refiners had received the residues (red and white oils and tar) as payment for the refining. In Formosa the cheaper cost of production renders the conditions more favorable. Only a small quantity of camphor is used in Japan, though as the Japanese are commencing the manufacture of celluloid, the consumption will increase.

**Accumulator Plates.** F. FISCHER. (*Z. Elektrochem*, xvi, 355.)—The large unprepared lead plates are first oxidized so as to form a coating of lead monoxide by making them anodes in the electrolysis of a 10 per cent. solution of sodium phosphate at 80° C., between cathodes of the same area. The E. M. F. is allowed to rise during the process from 2.2 to not more than 2.6 volts. In 24 to 36 hours the plates are covered with a firm coating of lead

monoxide. This is then reduced to spongy lead by electrolysis of so-called accumulator acid (sp. gr. 1.18) at room temperature with 1 ampère per sg. dcm. until hydrogen is given off. The plates are then washed for 12 hours, and the coating is oxidized to lead peroxide on half of them, by making them anodes in a similar electrolysis of a more dilute acid of sp. gr. 1.09. An uninterrupted current of 1 ampère per sg. dcm. must be passed until oxygen is freely evolved. The reduction requires about as long as the formation of the original coating, the oxidation about twice as long; the whole process requires 4 to 5 days.

**Chemical Effects of Ultra-Violet Rays on Gases.** D. BERTHELOT and H. GAUDECHON. (*Comptes rendus*, cl, 1327.)—Under the influence of the ultra-violet rays, cyanogen is practically completely oxidized to carbon dioxide and nitrogen. A mixture of ammonia and oxygen yields nitrogen and water, but free hydrogen is not oxidized appreciably by oxygen at the ordinary temperature under similar conditions. Formic acid is produced by the action of ultra-violet rays on mixtures of acetylene and ethylene with oxygen.

**Production of Metallic Deposits.** U. SCHOOP. (*Comptes rendus*, cl, 1044.)—Objects can be covered with a deposit of any fusible metal or alloy, by forcing the fluid metal through a suitable jet by the pressure of some inert gas. A coating can thus be produced upon almost any material from 0.02 mm. to several mm. in thickness. The temperature of the metallic stream just beyond the jet is between 10° and 60° C. A high pressure of 20–25 kilos per sq. cm. should be used. Tin, lead, copper and aluminum and its alloys can be deposited by this process.

**Diffusion of Certain Coloring Matters.** LEO VIGNON. (*Mon. Sci.*, xxiv, 821.)—The chemical type appears to have no influence on diffusion. Coloring matters, which have no diffusible power, are marked by a strong molecular condensation; they exist, in a condition of pseudo-solution, as solid granules which are extremely minute, and do not change the limpidity of the solution as apparent to the unaided eye. Coloring matters of this type are called *substantive;* they adhere indifferently upon all textiles, on account of their molecular attraction, after the manner of insoluble coloring matter. Their fixation is facilitated by the very fine division of the granules. In fact the study of diffusion shows that coloring matters form two well defined groups; those of the first group give true solutions (of the type of picric acid); those of the second group are, to speak accurately, insoluble and form pseudo-solutions (of the type of congo red).

PRESS OF
J. B. LIPPINCOTT COMPANY
PHILADELPHIA